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"A comparative approach to livestock-wildlife interactions in central Europe and sub-Saharan Africa"

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Zusammenfassung

Trotz deutlicher Unterschiede zwischen den Ökosystemen Mitteleuropas und denen im südlichen Afrika existieren starke natürliche und kulturelle Verbindungen. Aufgrund von Parallelen in der Domestikationsgeschichte, fungieren europäische und afrikanische Hausrinder als theoretischer Rahmen der vorliegenden Dissertation. Auch wenn der Auerochse (*Bos primigenius*) den Ursprung der Hausrinder in beiden geografischen Regionen darstellt, kam er im Gegensatz zu Europa nicht im südlichen Afrika vor. Diese Dissertation, die sich mit Wechselwirkungen zwischen Weidevieh und Wildtieren befasst, wurde als eine vergleichende Studie konzipiert. Sie basiert auf der zentralen Hypothese, dass sich vergleichsweise stark transformierte europäische Landschaften und weniger gestörte afrikanische Savannen gegenseitig als Referenz dienen können. Innerhalb von vier Fallstudien wurde ein Forschungsansatz angewendet, der auf der Analyse von Kamerafallendaten, Fragebögen und Interviews basiert. Die Daten wurden jeweils in räumlicher Nähe zu Schutzgebieten in Deutschland (Nationalpark Unteres Odertal und Naturpark Westhavelland), Namibia (Etosha Nationalpark) und Tansania (Serengeti Nationalpark) erhoben. Mittels Kamerafallen wurden Reaktionsmuster von Wildtieren bezüglich verschiedener Weidesysteme für Nutztiere analysiert. Parallel durchgeführte Interviews und Fragebögen lieferten detaillierte Informationen zum Weidemanagement und damit verbundenen Mensch-Wildtier-Konflikten. Erwartungsgemäß gab es regionsspezifische Unterschiede zwischen den Ergebnissen aus Afrika und denen aus Europa. So deutet vieles darauf hin, dass in den europäischen Fallstudien das Bewusstsein für nachhaltiges Weidemanagement stärker ausgeprägt ist als in den afrikanischen Fallstudien. Die Ergebnisse aus den Untersuchungsgebieten in Deutschland, wo Weidehaltung von Nutztieren regelmäßig zu Naturschutzzwecken eingesetzt wird, zeigen, dass die folgenden Elemente des Weidemanagements die Nachhaltigkeit der Weidehaltung fördern: 1. Anpassung der Tierbestände an die verfügbare Weide, 2. Mobilität des Weideviehs, 3. zusätzliche Fütterung in Zeiten mit wenig Weideaufwuchs. Es kann davon ausgegangen werden, dass die genannten Praktiken Potential haben, die Nachhaltigkeit der Weidetierhaltung in Afrika zu erhöhen, indem sie Überweidung vorbeugen. Ähnliche Reaktionsmuster von Wildtieren auf verschiedene Weidesysteme in Deutschland (Wechselweide und „Wilde Weide“) führen zu einer kritischen Bewertung des Nutzens der sogenannten „Wilden Weide“. Beim Vergleich der zirkadianen Aktivitätsmuster der Nutztiere fällt auf, dass diese in Afrika weniger nachtaktiv waren als in Europa. Dies kann mit der größeren Bedrohung durch Karnivoren in Afrika und damit verbundenem Antiprädatorverhalten erklärt werden. So sollte der Erhalt traditioneller Rinderrassen nicht vernachlässigt werden, da diese, ähnlich wie in Afrika, für Weidesysteme in Europa an Bedeutung gewinnen werden, wenn Wechselwirkungen mit Wildtieren zunehmen (z.B. durch Wiederansiedlung lokal ausgestorbener Großsäuger und Klimawandel). Im Gegensatz zu den afrikanischen Untersuchungsgebieten gibt es in Deutschland Kompensation von durch Wildtieren verursachten Schäden. Durch die höhere Artenvielfalt der afrikanischen Wildtierzönose im Vergleich zur Europäischen ist in Afrika die Konkurrenzbeziehung zwischen Wild und Weidevieh deutlich stärker ausgeprägt als in Europa. Zum Beispiel zeigen die Ergebnisse

aus der Etosha-Region signifikant niedrigere relative Abundanz von überwiegend großen Huftierarten im Zusammenhang mit der Beweidung von Nutztieren. In Afrika waren die Reaktionen der Wildtierzönosen auf verschiedene Weidesysteme stärker ausgeprägt. Das Spektrum an messbaren Effekten bei unterschiedlicher Beweidungsintensität war hier viel größer als in Europa. Der Vergleich von phylogenetisch eng verwandten Wildtierarten, oder solchen mit ähnlichen ökologischen Funktionen in europäischen und afrikanischen Biozönosen, zeigt regionsspezifische Unterschiede (z. B. Änderung der relativen Abundanz von kleinen Blattäsern) aber auch gemeinsame Reaktionsmuster (z. B. Änderung der relativen Abundanz bei Suiden und mittelgroßen Kaniden). Weitere, in allen vier Fallstudien unabhängig vom Weidesystem identifizierte, Gemeinsamkeiten waren die mit der Anwesenheit von Nutztieren verbundene signifikante Verringerung der gesamten Wildtieraktivität (relative Abundanz). Desweiteren stehen sich in allen Untersuchungsgebieten Landwirte und Naturschützer mit unterschiedlichen Zielen gegenüber, wobei die Landwirte nicht generell gegen Wildtiere sind. Es gab jeweils Konflikte mit einigen Wildtierarten, wobei sich die Viehhalter in diesem Zusammenhang nicht ernst genommen fühlen. Ein gemeinsames Phänomen sind hohe Mensch-Wildtier-Konflikte mit streng geschützten Wildarten (Wolf in Deutschland und Elefant in Afrika). Die Ergebnisse zeigen, dass diese Arten ohne Bejagung nicht konfliktlos neben der Weidetierhaltung existieren können. Der Vergleich von Strategien aus Europa und dem südlichen Afrika zeigt, dass Entschädigungszahlungen, selbst wenn sie mit Präventivmaßnahmen kombiniert werden (Europa), nicht die Bejagung (Afrika) ersetzen können. Die vielversprechendste vorbeugende Maßnahme zur Prädationsvermeidung bei Rindern sind besonders geschützte Weiden für Kälber in der Nähe menschlicher Siedlungen. Die Ergebnisse zeigen aber auch, dass eine Koexistenz von Wildtieren mit der Weidetierhaltung nur möglich ist, wenn konfliktverursachende Wildtiere entnommen werden und Populationen reguliert werden. Im Allgemeinen deuten die Ergebnisse dieser Untersuchungen darauf hin, dass Schutz und Erhalt von Agrobiodiversität nur erfolgreich sein können, wenn die Managementstrategien den Anforderungen der Landwirte gerecht werden. Die Ergebnisse beider Methoden zeigen mehrere Gemeinsamkeiten zwischen den Untersuchungsgebieten in Deutschland und dem privaten Farmland in Namibia. So wird die Rotationsweide als ein in europäischer Kulturlandschaft entwickeltes Weidesystem auch in Afrika praktiziert. Jedoch ist dabei eine sorgfältige Überlegung und Anpassung an die standortspezifischen Bedingungen erforderlich. Die Ergebnisse aus der Serengeti-Region zeigen dagegen ein deutlich anderes Bild. Sie sind ein Indikator für die extreme Veränderung der Landschaft und ausgeprägte Mensch-Wildtier-Konflikte. Besonders dort, wo Rinder eine hohe kulturelle Bedeutung haben, ist es nötig, die Menschen für Nachhaltigkeit im Weidemanagement zu sensibilisieren. Die Ergebnisse dieser Studie lassen vermuten, dass traditionelle Praktiken des gegenwärtig verschwindenden Pastoralismus Potential haben, um die ökologische Nachhaltigkeit der Weidehaltung auf kommunalem Land in Afrika zu verbessern. Grundsätzlich unterstreichen die Ergebnisse dieser Dissertation die Bedeutung von vergleichenden Studien für ein besseres Verständnis von Wechselbeziehungen zwischen Nutz- und Wildtieren. So gewonnene neue Erkenntnisse können zur Entwicklung von effektiven Managementpraktiken auf überregionaler Ebene beitragen.

Summary

Despite pronounced differences between grassland ecosystems in temperate Europe and sub-Saharan Africa, there are strong natural and cultural connections. Given parallels in domestication history, cattle is functioning as theoretical framework of this thesis. Although the aurochs (*Bos primigenius*) represents the origin of cattle in both geographical regions, it contrary to Europe did not inhabited sub-Saharan Africa. This study, which addresses the topic of livestock-wildlife interactions in distinct grassland ecosystems in central Europe and sub-Saharan Africa uses a comparative approach. The thesis is based on the central hypothesis that highly transformed European landscapes and less disturbed African savannas can provide each other a valuable reference. A mixed-methods approach, comprising camera-trap surveys, questionnaires and problem-centred interviews, was applied in a series of four case studies. The data were collected adjacent to different protected areas in Germany (Lower Oder Valley National Park and Westhavelland Nature Park), Namibia (Etosha National Park) and Tanzania (Serengeti National Park). Camera-traps were used to comparatively analyse wildlife response patterns to different livestock grazing systems. Parallel conducted stakeholder-interviews and questionnaires provided detailed information on pasture management and associated human-wildlife conflicts.

As expected, there were region-specific differences between the results from sub-Saharan Africa and those from central Europe. It suggests that the awareness for sustainable pasture management is less pronounced in Africa when compared to Europe, where livestock grazing is regularly used for landscaping. The following factors turned out to support the sustainability of livestock grazing in Germany: 1. adaptation of livestock numbers to the available pasture, 2. livestock mobility, 3. additional feed during times of shortage. These practices can be assumed to improve the sustainability of livestock farming in the African context, due to prevention of overgrazing. Comparable response patterns of wildlife to different livestock grazing systems in Germany (rotational grazing vs. "naturalistic grazing") lead to a critical evaluation of the benefits of "naturalistic grazing". When comparing the daily activity patterns of livestock, it is obvious that livestock was less active during night-hours in Africa than in Europe. This can be explained with the higher pressure by carnivores in Africa and associated anti-predator behaviour of livestock. Thus, the preservation of traditional cattle breeds should not be neglected, as these, similar to the African context, will gain in importance for grazing systems in Europe, when interactions with wildlife increase (e.g. due to "rewilding" and climate change). In contrast to the African study areas, there are systems for the compensation of economic losses, caused by wildlife in Germany.

Owing to the higher species richness of African wildlife community compared to the European wildlife community, the competitive relationship between wildlife and livestock is much more pronounced in Africa. The results from Etosha Region, for instance, reveal significant lower relative capture frequencies of predominantly large naturally occurring ungulates in association with livestock grazing. Responses of African wildlife communities to livestock grazing were more pronounced compared to those in Europe. The spectrum of measurable effects on different grazing intensities was much wider in Africa when

compared to Europe. The comparison of phylogenetically closely related wildlife species, or those with similar ecological functions in European and African wildlife communities, reveals region-specific differences (e.g. within-site change in RCF of small browsers) but also common response patterns (e.g. within-site change in RCF of medium-sized canids and suids). This was not the only identified common pattern between the different observed geographical regions. A cross-regional phenomenon in all four case studies was that, regardless of the different grazing system, presence of livestock was associated with a significant reduction in total wildlife activity (relative capture frequency, RCF). Further, there was a region-specific difference in the daily activity patterns of livestock (less active during night in Africa).

In all study areas, there are livestock farmers and conservationists, which have conflicting goals. Although farmers are not generally against wildlife, there are conflicts with certain wildlife species. A common phenomenon is that farmers feel that they are not taken seriously in this context. A common feature among all study areas is that strictly protected wildlife species, in particular wolf (*Canis lupus*) in Germany and elephant (*Loxodonta africana*) in Africa, are responsible for high human-wildlife conflict with livestock farmers. The results indicate that lethal control measures are required for these strictly protected wildlife species in order to ensure coexistence with livestock grazing. It is very doubtful that compensation schemes (e.g. for wolf in Europe) and preventive measures can replace lethal control measures. The most promising measure to prevent cattle predation by large carnivores is to set up particularly protected pastures for calves near human settlements. The results also suggest that coexistence with animal husbandry is only possible, when conflict-causing individuals of wildlife are consequently removed and populations of conflicting wildlife species are regulated. In general, the results of this thesis indicate that protection and conservation of agro-biodiversity can only be successful, if management strategies meet farmers' requirements. The results of both approaches show various similarities between the study areas in Germany and the private farmland in Namibia. This shows that rotational grazing, as a grazing system developed in the European cultural landscape, also works on commercial farmland in the African context. However, careful consideration and adaptation of grazing practice to site-specific conditions is needed. The results from the Serengeti region, however, show a very different picture. These are an indicator of the extreme transformation of the landscape and pronounced human-wildlife conflict. In regions, where cattle has immense cultural value, it is necessary to sensitize people to the topic of sustainability in pasture management. Traditional practices of currently disappearing pastoralism could have potential to improve the ecological sustainability of livestock farming on communal land in Africa. Collectively, the results of this dissertation emphasize the importance of comparative studies for a better understanding of ecological relationships. As shown here, the comparative approach has potential to clarify the effects of land use systems on selected biodiversity parameters. The new insights gained in this way can help to develop more effective management strategies. A better understanding of livestock-wildlife interactions is supposed to contribute to the development of more sustainable livestock grazing on a transnational scale.

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Acronyms

BP	Before present
CBD	Convention on Biological Diversity
et al.	Et alii / et aliae
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GPS	Global Positioning System
HVL	Havelland
HWC	Human-wildlife conflict
IQR	Interquartile range
IUCN	International Union for Conservation of Nature
LOV	Lower Oder Valley
n	Sample size
NAM	Namibia
NGO	Nongovernmental organisation
no.	Number
NP	National park
PC	Personal computer
PCI	Problem-centred interview
RCF	Relative capture frequency
S-test	Spearman's rank test
TSZ	Tanzania Shorthorn Zebu
TZ	Tanzania
UN	United Nations
WMA	Wildlife management area
W-test	Wilcoxon test

1 Introduction

Our generation faces a loss of biodiversity as none before in human history (Reid et al., 2005). The recent 14th conference of the UN Convention on Biological Diversity (CBD) in November 2018 highlights the relevance of the topic. Human activities are considered as major challenges for future conservation of biodiversity (Caro et al., 2012). The intensification of agricultural practices and associated land use changes are important factors involved in the global decline in biodiversity (Foley et al., 2005; Ogutu et al., 2009; EEA, 2010; Nebold et al., 2015; Zeller and Göttert, 2019). Large mammals, commonly used as flagship species for nature conservation (Sinclair, 2003) are particular threatened due to human activities (Cardillo et al., 2005; Marco et al., 2014). Given the global relevance of the subject (Foley et al., 2005; Marco et al., 2014; Nebold et al., 2015), comparative approaches comprising different geographical regions appear suitable to assess the impact of land use on agro-biodiversity. Zeller et al. (2017) postulated a comparative approach to grassland ecosystems in distinct geographical regions (ecological conditions) of central Europe and sub-Saharan Africa. Although these regions and ecosystems appear to have little in common at first glance, there are several striking natural and cultural parallels. These include the Afro-Palearctic bird migration system (Newton, 2008), biogeographical relations between continents (Meulenkamp and Sissingh, 2003), faunal similarities during the late Pleistocene (Kahlke, 1986; Pushkina, 2007) and the domestication history of European and African cattle (Hanotte et al., 2000).

1.1 Large mammals and their ecological function in grassland ecosystems

Whereas the recent savannas of sub-Saharan Africa are thought to have developed before the Pleistocene (e.g. Namibia and Tanzania 5 Ma; Jacobs et al., 1999), central Europe's landscapes were shaped by several glaciations until the beginning of the Holocene (11,500 BP) (Roberts, 2013) and can be considered as a result of climatic events and human activities (Vera et al., 2006). However, similar ecological processes are assumed to appear in central European and sub-Sahara African grassland ecosystems (Zeller et al., 2017). Large mammals are known to have significant ecosystem shaping capability (McNaughton et al., 1997; Sinclair, 2003) and even seem to have co-evolved with grassland ecosystems (Stebbins, 1981). Similar to current African savannas, the European landscapes were characterized by a diverse community of large herbivores during the Eem-interglacial (132,000-110,000 BP), causing a permanently altering mosaic of semi-open habitats (Johnson, 2009; Sandom, et al., 2014). However, in contrast to the African continent, Europe experienced a dramatic reduction in megafaunal species diversity following human colonization and climatic changes during late Pleistocene (Bartlett et al., 2016). The applied comparative approach leads to the conclusion that the remaining relatively undisturbed savanna ecosystems in sub-Saharan Africa may function as reference for a better understanding of the interrelationships within highly transformed European ecosystems (Figure 1).

Reconstructions of the vegetation in central Europe based on data from the early Holocene lead to the assumption that the area was covered by dense forests (Dinnin and Sadler, 1999), which can be explained by the loss of various ecosystem shaping larger herbivores and should not be seen as a natural condition (Vera et al., 2006). Consequently, Sandom et al. (2014) proposed using the situation before the latest glacial period as baseline to explain the impact of megafaunal extinctions on the vegetation of European ecosystems. The origin of agriculture goes back to the domestication of plants and animals during the Neolithic (Diamond, 2002). With its spread, European landscapes have changed from about 5,000 years ago (Dinnin and Sadler, 1999). Associated anthropogenic activities led to extinction of larger native herbivores and carnivores (Crees et al., 2016). Traditional farming practices have caused an increase of structural complexity in European landscapes and related species diversity (ELO, 2010). Domesticated animals have partly replaced the ecosystem shaping function of the decimated naturally occurring herbivores (Vera et al., 2006). Compared to the structurally uniform forests, the resulting secondary grasslands favour a large number of species and can be considered as habitat types of high ecological value (Paracchini et al., 2008). Given their origin, these ecosystems benefit from extensive traditional land use, particularly livestock grazing (EEA, 2010; Wrage et al., 2011). However, recent intensification of livestock farming is associated with a widespread decline of livestock grazing (FAO, 2016). Despite their particular value for nature conservation grasslands are often not used any longer for economical reasons and are thus threatened by succession of woody vegetation (EEA, 2012). Consequently, grazing of domesticated herbivores represents a significant management tool for landscaping (preservation of European grasslands) (Vera et al., 2006; Paracchini et al., 2008; Rosenthal et al., 2012).

Figure 1: Secondary European grassland in Lower Oder National Park - Germany (left) versus less disturbed African savanna at Marienfluss in northern Namibia (right)

Although, the vegetation dynamics in Europe at the transition from Pleistocene to Holocene confirm the importance of naturally occurring large herbivores for open habitats (Vera et al., 2006), a similar development can be observed in African landscapes. Semi-arid savannas cover about 65% of the African continent (Augustine, 2004) and accommodate a diverse assemblage of large naturally occurring mammals (Craigie et al., 2010). In Europe, no comparable faunal assemblage has survived (Bartlett et al., 2016). African savannas comprise open grassland with occasional woody vegetation, rainy and dry seasons as well as field fires (Huntley, 1982). These ecosystems are characterized by spatial and temporal variability of resources (e.g. Ogutu and Owen-Smith, 2003; Durant, 2017) and have developed through associated movements of large naturally occurring herbivores (Dublin, 1995; McNaughton et al., 1997), which have shaped the landscape for at least 40 million years (Olff and Hopcraft, 2008). The African continent is famous for the most comprehensive seasonal long-distance wildlife migrations (e.g. Serengeti-Mara ecosystem), although aggregated movements of large terrestrial mammals can still be found in other geographical regions including parts of Europe (Harris et al., 2009). African savannas support the richest diversity of naturally occurring larger mammals on earth (e.g. Bartlett et al., 2016). At the same time, these ecosystems are mainly used for livestock grazing (Augustine, 2004; Notenbaert et al., 2012), crucial for the livelihoods in semi-arid rural areas (Homewood, 2008). Both, wildlife and livestock used to move between low-rainfall areas in the wet seasons and wetlands in the dry-seasons (Macandza et al., 2012). Thus, the heterogeneity of rangelands and in particular the wetlands are crucial (e.g. Little, 1996; Fynn et al., 2016; Tyrrell et al., 2017). In contrast to central Europe, where livestock grazing is important for nature conservation (e.g. Vera et al., 2006; Paracchini et al., 2008; Rosenthal et al., 2012), livestock farming in the African context is usually recognized as destructive and responsible for declining wildlife populations (e.g. Ogutu et al., 2009; 2016). In fact, the intensification of land use and associated changes of traditional grazing practices (decline of livestock mobility) have negative ecological impact on African savannas (e.g. Niamir-Fuller, 1999; Galvin, 2009; Ogutu et al., 2009; Western et al., 2009). For instance bush encroachment is a widespread phenomenon in African savannas (e.g. Trollope, 1982; Mendelsohn et al., 2002; Ward, 2005; Sinclair et al., 2008; Otuoma et al., 2009). Next to heavy livestock grazing (e.g. Tobler et al., 2003; Asner et al., 2004; Coetzee et al., 2008), bush encroachment is thought to be caused by low abundance of native browsing herbivores, low frequency of fires (Dublin, 1995; Scholes and Archer, 1997; Augustine et al., 2011; O'Connor et al., 2014) and climatic changes (Asner et al., 2004; Morgan et al., 2007). Degraded rangelands are neither suitable for sustainable livestock grazing (Scholes and Archer, 1997) nor for wildlife conservation and ecotourism (Treydte et al., 2005).

1.2 Significance of farmland for wildlife conservation

Habitat loss through human activities is considered as main cause of wildlife extinction in central Europe and sub-Saharan Africa (Biggs et al., 2008; Temple and Terry, 2009; Fitzgerald, 2015). More conservation effort is required to respond to declining wildlife numbers (e.g. Temple and Terry, 2009; Craigie et al., 2010; Fynn and Bonyongo, 2011; Ogutu et al., 2016). The idea of conserving biodiversity goes back to the middle of the last century. The International Union for Conservation of Nature (IUCN), which was founded in 1948, for instance defines seven categories of protected areas (EEA, 2012).

Figure 2: Preservation of cultural landscape through cattle grazing in Berchtesgaden National Park, Germany (left) versus migration of wildebeest in Serengeti National Park, Tanzania (right)

On the one hand, conservation focuses on a still-existing Pleistocene megafaunal assemblage and associated natural phenomena, such as some of the last existing seasonal long-distance wildlife migrations in Africa (Harris et al., 2009). On the other hand, conservation in Europe focuses on diverse semi-natural ecosystems, as natural ecosystems have almost vanished (EEA, 2010a; Figure 2). In fact, European nature conservation concepts (e.g. Natura 2000) aim to protect cultural landscapes addressing increasing biodiversity levels in moderately disturbed ecosystems (Ostermann, 1998). Given pronounced territorial behaviour and species-specific migration patterns of terrestrial mammals, comprehensive habitats are required for effective wildlife conservation (Herrmann and Müller-Stiess, 2003). This applies for both, ungulates and carnivores (Harris et al., 2009; Hoogesteijn, 2001). The free movement of wildlife is essential to cope with seasonal availability of resources (DeFries et al., 2007; Harris et al., 2009) and for the exchange of genetic material of otherwise isolated populations (Herrmann and Müller-Stiess, 2003). Thus, clearly defined protected areas have been proven unsuitable for sustainable conservation of wildlife (e.g. Thirgood et al., 2004; Newmark, 2008; Harris et al., 2009; Craigie et al., 2010; Fynn and Bonyongo, 2011; DeFries et al., 2007). Although much more extensive compared to Europe (EEA, 2012),

many African protected areas do not allow for sufficient wildlife mobility (Barnard et al., 1998; Fynn and Bonyongo, 2011). The establishment of protected area networks is supposed to improve habitat connection (Wells et al., 1992; Newmark, 2008; EEA, 2012). There are trans-boundary protected area networks in both, sub-Saharan Africa (e.g. Peace Parks Foundation [King, 2010] and Serengeti-Mara Ecosystem [e.g. Olff and Hopcraft, 2008]) and central Europe (e.g. Natura 2000 [Ostermann, 1998] and Lower Oder National Park [Vössing, 2011]).

Protected areas are often ineffective for sustainable conservation of biodiversity, as they usually exclude neighbouring human communities, though associated farmland is important for wildlife (e.g. Wells et al., 1992; DeFries et al., 2007). For effective conservation of biodiversity, protected areas depend on adjacent land, which is crucial for wildlife mobility (e.g. Wells et al., 1992; Barnard et al., 1998; Fynn and Bonyongo, 2011; DeFries et al., 2007). Particularly grassland-dominated ecosystems have significant potential for both, preservation of biodiversity and livestock farming (Little, 1996; Jacobs et al., 1999; Prins, 2000; Tyrrell et al., 2017). However, human activities increasingly cause fragmentation of farmland in both, temperate Europe and sub-Saharan Africa, restrict wildlife mobility (Herrmann and Müller-Stiess, 2003; Hobbs et al., 2008; Otuoma et al., 2009; Groom and Western, 2013). Unsustainable use of natural resources is known to reduce the resistance of ecosystems towards climate change and therefore contribute to degradation of habitats and biodiversity loss (EEA, 2010a).

1.3 A common origin of European and African cattle

Both, European and African cattle originate from the aurochs (*Bos primigenius*) and thus have to be considered as representatives of this "stem species"[1] (Zeller and Göttert, 2019). The aurochs became extinct due to human activities by 1627 (Epstein, 1971; Felius, 1995; Ajmone-Marsan et al., 2010). At the transition from Pleistocene to Holocene, the aurochs inhabited vast temperate and subtropical regions of Eurasia as well as parts of northern Africa (Epstein, 1971; Felius, 1995). Within this large distribution range (Figure 3), the species revealed different phenotypic variations (Epstein, 1971; Porter, 1991; Felius, 1995; Van Vuure, 2002). This inter-specific variability and distinct regional nuclei of domestication led to a unique domestication history of the aurochs, as more than one domestic form derived from one and the same "stem species".

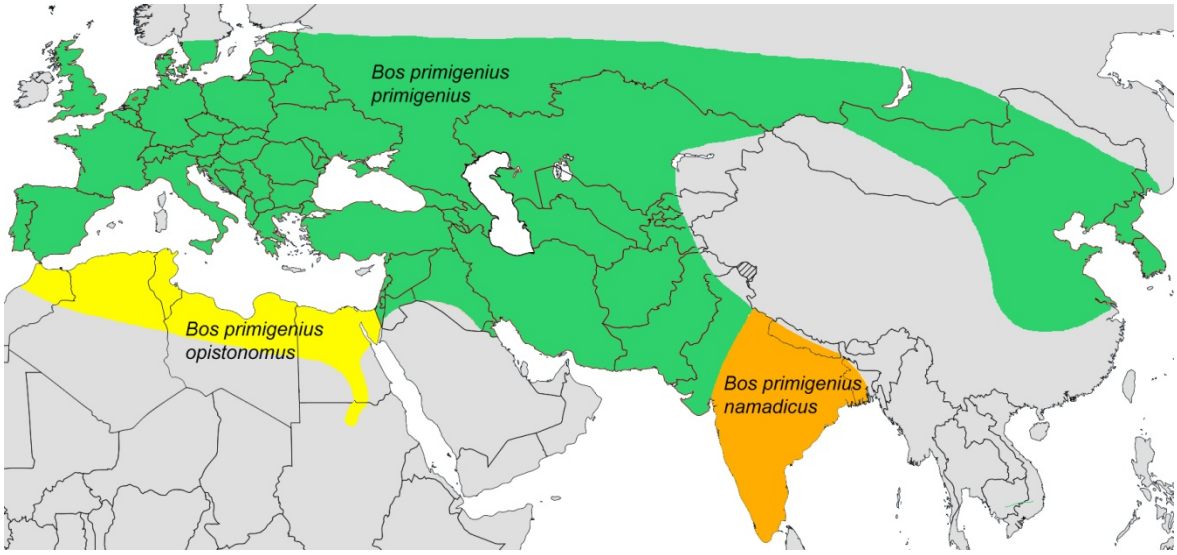

Figure 3: The historical distribution and morphological variations of the aurochs during Pleistocene and Holocene (modified from Van Vuure, 2002)

Archaeological findings let assume, that aurochs could become larger than cattle (Felius, 1995; Helmer et al., 2002; Van Vuure, 2002). An aurochs bull had a body weight up to 1,000 kg and in average measured 180 cm at the withers (Epstein, 1971; Porter, 1991; Felius, 1995). The black aurochs bulls were obviously taller than the brownish females (Zeuner, 1963; Porter, 1991), while sexual dimorphism is less pronounced in cattle (Helmer et al., 2002). Characteristic for the aurochs were the long horns, which in average measured 80 cm at the bulls (Felius, 1995).

[1] In the present work, the term "stem species" is given in quotation marks in order to distinguish from the stem species concept in phylogenetic systematics.

There is genetic evidence for the independent domestication of different aurochs ecotypes (*Bos primigenius primigenius* and *Bos primigenius namadicus*) in distinct regions (Epstein, 1971; Bradley et al., 1998). The first domestication occurred in Mesopotamia on the western Arabian peninsula not later than 10,300 BP, resulting in the taurine cattle (*Bos primigenius* f. taurus) (Helmer et al., 2002). At a later stage, an independent domestication process began on the Indian subcontinent about 7,000 years ago, which led to the indicine cattle (*Bos primigenius* f. indicus), also referred to as humped cattle or zebu (Epstein, 1971). From these two domestication centres, cattle spread out over the European and African continent (Felius, 1995; Figure 4).

Taurine cattle (*Bos primigenius* f. taurus) reached Europe and Africa via Neolithic human migrations from the domestication centre in Mesopotamia (Epstein, 1971; Felius, 1995). First cattle (longhorn) entered Europe about 8,800 years ago (Edwards et al., 2007) and had spread out all over Europe by 6,500 to 4,000 years ago (Felius, 1995). The main migration routes were along the coast of the Mediterranean Sea and the river Danube (Pinhasi at al., 2005; Taberlet et al., 2008). Ancient cattle in Europe and Africa were interbred with the local ecotypes of aurochs (Bradley, 1998; Decker et al., 2014). Since cattle were transported across the Strait of Gibraltar, there is an influence of African aurochs in European cattle breeds as well as influence of European taurine cattle in breeds of northern Africa (Decker et al., 2014). Whereas there are several longhorn breeds on the Iberian Peninsula (Felius, 1995), most long horned cattle was replaced by short-horned breeds over the last 5,000 years for easier handling in dairy production (Porter, 1991).

The origin of African cattle is rather complex and not finally clarified (Ajmone-Marsan et al., 2010; Decker et al., 2014). Archaeological findings from the Sahara region reveal, that first African cattle was certainly taurine (Epstein, 1971; Bradley et al., 1998; Hanotte et al., 2002). There are two major theories about the origin of initial African cattle (Felius, 1995; Hanotte et al., 2002). Based on genetic analyses of archaeological findings some scientists propose an autochthon domestication of cattle on the African continent (Grigson, 1991; Wendorf and Schild, 1994; Gabriel, 2002; Hanotte et al., 2002). However, there is a more common theory about the domestication history of African cattle (Figure 4). The import of taurine longhorn cattle about 8,000 years ago (Felius, 1995) was followed by one of taurine cattle with short horns about 4,750 and 4,500 years ago (Epstein, 1971). The indicine form of cattle, is thought to have been introduced to the Horn of Africa about 4,000 to 3,500 BP (Epstein, 1971). The African ecotype of aurochs, which probably had influence on the African cattle (Decker et al., 2014), disappeared in Egypt about 3,400 BP and went completely extinct 1,500 years ago (Epstein, 1971). The typical African Sanga cattle is supposed to be a result of initial crossbreeding with taurine longhorn cattle (*Bos primigenius* f. taurus) in the Horn of Africa (Epstein, 1971; Felius, 1995; Hanotte et al., 2002). Sanga cattle gradually spread out southwards with nomadic tribes (Porter, 1991; Felius, 1995). First evidence of cattle in southern Africa (Botswana)

dates to 290 AD (Denbow and Wihnsen, 1986). By 700 AD, cattle reached Cape Agulhas (Felius, 1995). During crossing the African continent, cattle became particular adapted to the extreme environment (Grigson, 1991). Additionally intensive imports of indicine cattle by the Arabs along the African east coast from about 700 AD (Epstein, 1971; Bradley et al., 1998) have had significant influence on the African cattle (Hanotte et al., 2000). Due to morphological differences indicine cattle can better cope with tropical climate compared to taurine cattle (Bartha, 1971; Grigson, 1991). Moreover, indicine cattle were less affected by the rinderpest epidemic end of 19th century (Epstein, 1971; Felius, 1995). Consequently, zebus have spread on the African continent (Felius, 1995; Hanotte et al., 2000), permanently replacing and modifying the Sanga cattle (Grigson, 1991; Felius, 1995). The zebu influence on African cattle is most pronounced in the east of the continent and declining to the southwest (Bradley et al., 1998). Through geographical isolation, the zebu influence is yet less pronounced in South African Sanga cattle (Hanotte et al., 2000). Whereas indicine influence in European cattle can be exclusively found in some Italian breeds (Decker et al., 2014), the African continent represents the major zone of crosses from taurine and indicine cattle (Bradley et al., 1998). Progeny of the early taurine cattle, which have not been interbreed with zebus are restricted to the Mediterranean coast and to tsetse fly infested areas in western Africa (Epstein, 1971; Porter, 1991).

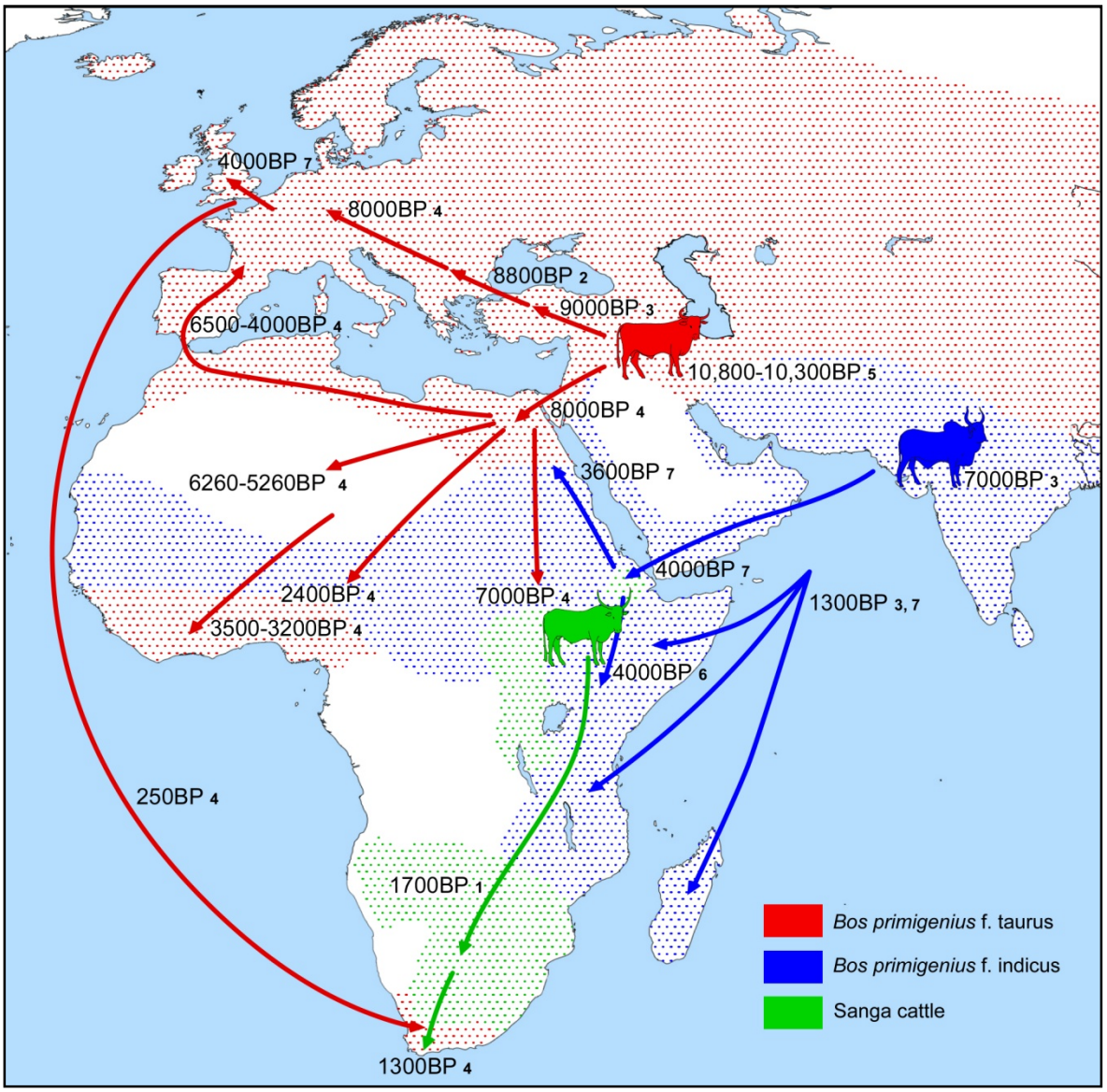

Figure 4: Common theory about the origin of cattle in Africa and central Europe (1: Denbow and Wihnsen, 1986; 2: Edwards et al., 2007; 3: Epstein, 1971; 4: Felius, 1995; 5: Helmer, 2002; 6: Marshall, 1998; 7: Porter, 1991) and the proximate distribution of taurine, indicine and Sanga cattle (modified from Porter, 1991; Felius, 1995).

Next to the described linkage in the domestication history of European and African cattle, there is a more recent connection. Human selection over millennia has resulted in more than 1,000 different cattle breeds (Felius, 1995), particularly adapted to local environmental conditions (Porter, 1991). After initial import to southern Africa by Dutch settlers in 1780 (Figure 4) European cattle breeds are frequently introduced since the middle 19th century to sub-Saharan Africa (Felius, 1995) in order to increase the productivity of cattle farming (FAO, 2007).

1.4 Livestock-wildlife interactions and related conflicts

Where grasslands represent pasture for wildlife and livestock, interactions between both usually cause human-wildlife conflict (Figure 5). The conditions for livestock farming are rather adverse in central Europe and sub-Saharan Africa. While the majority of large wildlife species is still present on the African continent since the Pleistocene, many naturally occurring species went extinct in Europe due to human activities (Bartlett et al., 2016). This includes the aurochs, which can be seen as autochthonous in Europe, but never inhabited sub-Saharan Africa (Figure 3). Although, cattle occurs in sub-Saharan African savannas for at least 1.700 years (Figure 4), it should be recognised as an exotic faunal element (Voeten and Prins, 1999). Despite pronounced interactions with wildlife (e.g. Schuette et al., 2016), grazing of cattle is traditionally a widespread land use strategy in Africa (e.g. Gabriel, 2002; Hanotte et al., 2002). Cattle has immense cultural value in sub-Saharan Africa (Doran et al., 1979; Milner-Gulland and Bennett, 2003; Olff and Hopcraft, 2008; Sinclair et al., 2008).

Several studies from sub-Saharan Africa, have shown disturbing effects of livestock on wildlife. Overuse of African savannas through livestock farming (increasing human pressure and land use changes) results in widespread degradation of rangelands and thus threatens livelihoods of people and wildlife through habitat loss (e.g. Trollope, 1982; Griffin, 1998; Scholes and Archer, 1997; Mendelsohn et al., 2002; Otuoma et al., 2009; Western et al., 2009; Bhola et al., 2012; Groom and Western, 2013). Further studies from this region reveal that grazing of cattle and other livestock is associated with a reduction in the abundance of naturally occurring herbivores (e.g. Kimuyu et al., 2017). This effect is particularly pronounced on rangelands located in close distance to human settlements, as well as on rangelands with high livestock densities (Ogutu et al., 2016; Schuette et al., 2016). An important driver seems to be competition over resources between livestock and naturally occurring herbivores (Happold, 1995; Little, 1996; Voeten and Prins, 1999; Prins, 2000; Galvin, 2009; Ogutu et al., 2009; Odadi et al., 2011; Fynn et al., 2015; 2016). While several studies in the African context approach the topic of livestock-wildlife interactions from a wild animal`s perspective (research focus is on wildlife responses toward livestock), this perception can hardly be found in the European context, where grazing of livestock is an important management tool in nature conservation (Vera et al., 2006; Paracchini et al., 2008; Rosenthal et al., 2012). Studies on livestock-wildlife interactions in Europe either focus on disease transmission between wild and domesticated animals (Kukielka et al., 2013), or predation of livestock by large carnivores (EC, 2014; Fechter and Storch, 2014).

Figure 5: Moose (*Alces alces*) joining cattle in Germany (left) and wildebeest (*Connochaetus taurinus*) grazing next to Maasai cattle in the Ngorongoro Conservation Area / Tanzania (right)

While African farmers have always been dealing with predation of cattle by larger carnivores (e.g. Homewood, 2008; Marshall, 1990; Fynn et al., 2015; Ogutu et al., 2016), this is a new experience for current European farmers (EC, 2014). Although Europe is the continent with the highest urbanization (Temple and Terry, 2009), there is a recent movement towards "rewilding" (Trouwborst, 2010; Helmer et al., 2015). Due to strict protection and pronounced ability to adapt to different habitats, populations of large carnivores (e.g. *Ursus arctos, Lynx lynx* and *Canis lupus*) are expanding rapidly after long time local extinction (Sillero-Zubiri et al., 2004; Trouwborst, 2010). Large carnivores require extensive protected areas (Hoogesteijn, 2001; Temple and Terry, 2009; Trouwborst, 2010). However, Europe's landscapes are characterised by infrastructural fragmentation and small structures and protected areas are not as spacious as on the African continent (EEA, 2012). Because of the long-time absence of predation risk, current grazing management does not comprise effective preventive measures (Sillero-Zubiri et al., 2004; EC, 2014). Moreover, naturally occurring ungulates have been partly replaced by domestic ones in European landscapes (Vera et al., 2006). Here the comeback of larger carnivores causes serious conflicts with farmers through livestock depredation (EC, 2014). Livestock predation is the most serious conflict with large canids and has major significance for conservation management (Boitani and Moehrenschlager, 2004). Effective management practices are needed to deal with livestock predation by particular grey wolf (*Canis lupus*) (e.g. Sillero-Zubiri et al., 2004; EC, 2014; Fechter and Storch, 2014).

Conflicting attitudes towards large carnivores can lead to serious public debate (EC, 2014). Whereas farmers recognize large carnivores mainly as threat for their livestock (Mendelsohn et al., 2002), the society in remote urban areas often support the idea of "rewilding" (Karlsson and Sjöstöm, 2007). People are fascinated due to the fact that these species are seen rarely. However, naturally carnivores are often nocturnal and less abundant compared to their prey species (Mendelsohn et al., 2002; Durant, 2017).

1.5 Problem statement

Our century is characterised by continuous human population growth (UN, 2017), while the limited agricultural land needs to sustain food security (ELO, 2010). However, intensification of agricultural practices and associated land use changes are important factors involved in the global decline of biodiversity (Foley et al., 2005; Ogutu et al., 2009; EEA, 2010; EEA, 2012; Nebold et al., 2015; Zeller and Göttert, 2019). As almost all landscapes are affected by biodiversity loss, conservation should not only focus on natural ecosystems (Sanderson et al. 2002). Humans use more than 25% of the globe`s terrestrial surface as grazing land (Asner et al., 2004). At the same time, grassland-dominated ecosystems have significant potential for the preservation of biodiversity (Jacobs et al., 1999; Prins, 2000; Paracchini et al., 2008; Ogutu et al., 2009; ELO 2010; Tyrrell et al., 2017). Although conditions for livestock farming are rather adverse in central Europe and sub-Saharan Africa, grazing of cattle is a land use strategy practiced for millennia in both geographical regions (Gabriel, 2002; Hanotte et al., 2002; ELO, 2010).

While Africa is the only continent that still harbours the majority of its Pleistocene megafaunal species diversity many respective wildlife species went extinct in Europe following human colonization (Bartlett et al., 2016). Consequently, it can be assumed that livestock-wildlife interactions differ between ecosystems that have lost many of the originally occurring primary consumer species (Europe) and ecosystems that still feature the vast majority of the originally occurring species (Africa). Further difference is supposed to result from the fact that cattle represent domesticated forms of an autochthon faunal element in Europe but an allochthon faunal element in sub-Saharan Africa. Given a number of parallels in domestication history, cattle offer a suitable framework for comparative studies (Zeller et al., 2017).

In order to achieve a more sustainable use of grassland ecosystems, a frame of reference is required that, as far as possible, reflects the interrelations between livestock grazing systems and associated agro-biodiversity. Large carnivores can have important regulating functions in ecosystems (e.g. Terborgh et al., 1999; Ray et al., 2005). However, does that also count for European cultural landscapes, where natural prey has been partly replaced by domestic animals? Wolves are able to kill large herbivores like wisent and moose (Okarma and Langwald, 2002), which are locally extinct in central Europe nowadays. Moreover, *Canis lupus* used to be the major natural enemy of the extinct aurochs in Europe (Van Vuure, 2002) and feeds on livestock including cattle when natural prey is limited (Okarma and Langwald, 2002; EC, 2014). Wolves are very flexible concerning prey species; they mainly feed on ungulates, whereby they take what is accessible the easiest and regularly kill more animals than they are able to consume (surplus killing) (Okarma and Langwald, 2002).

African livestock farming with its experience in dealing with the presence of predators is thought to serve as a valuable reference for a more sustainable management in highly transformed European landscapes (Zeller et al., 2017). At the same time practices from European grazing systems are supposed to have potential to improve the ecological sustainability of livestock farming in sub-Saharan Africa, where bush encroachment on rangelands is widespread (e.g. Trollope, 1982; Mendelsohn et al., 2002; Ward, 2005; Sinclair et al., 2008; Otuoma et al., 2009). Bush encroachment not only affects the quality of wildlife habitats (Griffin, 1998, Augustine et al., 2011; Fynn et al., 2016), but also reduces available grazing land for livestock (e.g. Scholes and Archer, 1997; Mendelsohn et al., 2002; Ward, 2005; Otuoma et al., 2009; Augustine et al., 2011).

An additional threat of agro-biodiversity refers to the genetic diversity of livestock. There is a global decline of cattle breeds through intensification of livestock farming (FAO, 2007; Taberlet et al., 2008), though high genetic diversity is particularly important in times of fast changing ecological conditions (FAO, 2016).

1.6 Objectives

The overall objective of this thesis is to improve the understanding of livestock-wildlife interactions in order to contribute to the development of more sustainable grazing systems, balancing the requirements of livestock farming and biodiversity conservation in temperate Europe and sub-Saharan Africa.

Specific objectives of the research:

- To identify common response patterns of wildlife (terrestrial ungulates and carnivores with at least four kilogram body weight) to different livestock grazing systems in central Europe and sub-Saharan Africa
- To comparatively evaluate the sustainability of local cattle grazing systems
- To evaluate stakeholder functions (livestock farming, wildlife conservation and hunting)
- To identify major regional HWC associated with livestock-wildlife interactions
- To identify practices, which have potential to effectively mitigate predation of cattle by large carnivores in Europe
- To identify management practices, which have potential to effectively mitigate ecological issues through livestock grazing in sub-Saharan Africa

1.7 Research questions

- Is there a common response of wildlife (occurrence and activity patterns of ungulates and carnivores ≥ 4 kg) to livestock grazing in central Europe and sub-Saharan Africa?
- How important do farmers in central Europe and sub-Saharan Africa consider the preservation of traditional cattle breeds?
- To what extend do stakeholder functions (cattle farming, wildlife conservation and hunting) differ in central Europe and sub-Saharan Africa?
- What causes major human-wildlife conflict associated with cattle grazing in central Europe and sub-Saharan Africa?
- Which management practices, inspired by practices of African farmers have potential to mitigate predation of cattle by large carnivores in central Europe?
- Which management practices have potential to improve the ecological sustainability of cattle farming in sub-Saharan Africa?

2 Methods

2.1 Study design

2.1.1 Case study research as a tool for European - African comparison

This thesis is based on the comparative analysis of four case studies in different geographical regions, comprising the identification of common patterns and region specific characteristics of livestock-wildlife interactions. According to Grosshans and Chelimsky (2003, p. 15), a case study is defined as "a method for learning about a complex instance, based on a comprehensive understanding of that instance obtained by extensive description and analysis of that instance taken as a whole and in its context." This research strategy was used, as the comparison of multiple case studies enables testing of hypothesis for their generalisation (Yin, 2014; Ridder, 2016).

Table 1: The applied mixed-methods approach

Research strategy	Case study analysis	
Approach	Natural sciences	Social sciences
Method	Camera trap surveys	Problem-centred interviews

This thesis comprises methods of both, natural and social sciences (Table 1). The combination of different methods can strengthen the research findings (Eisenhardt, 1989; Meijaard et al., 2011). The research design comprises a combination of camera trap- and interview surveys within four case studies. The combination of these two methods has potential to enable advice for efficient management strategies (Meijaard et al., 2011). Given various natural connections and cultural links these comparative studies focus on the distinct appearing ecosystems of central Europe and sub-Saharan Africa (Zeller et al., 2017). As it is not possible to investigate all ecological and socio-economical factors of the two comparative regions, the surveys were limited to four case studies (Thorton et al., 2007), here referred to as study areas. This was necessary, since the studies were supposed to enable meaningful results within the framework of a dissertation. Not only evidential value but also effort rises with increasing number of cases (Yin, 2014). As case study research is usually based on theoretical sampling (Ridder, 2016), study areas were carefully preselected based on assumptions. Given limited personal and technical resources, the case studies could not take place simultaneously, but were carried out one after another. All data were collected in the field to enable detailed insight into context-specific situations. After independent data analysis for each of the two applied methods (Table 1), findings were discussed on the basis of the defined research questions, whereby particular aspects from the camera trap surveys were linked with the results from the problem-centred interviews and compared with literature for strengthening and verification.

2.2 Study areas

Two case studies were conducted in central Europe (Germany) and two case studies took place in sub-Saharan Africa (Tanzania and Namibia). Since this thesis not only focuses on interrelations between livestock and wildlife, but also deals with edge effects associated with protected areas, the four case studies, here referred to as study areas, were selected within or in the neighbourhood of different protected areas: Lower Oder Valley National Park and Westhavelland Nature Park in Germany, Serengeti National Park in Tanzania and Etosha National Park in Namibia (Figure 6).

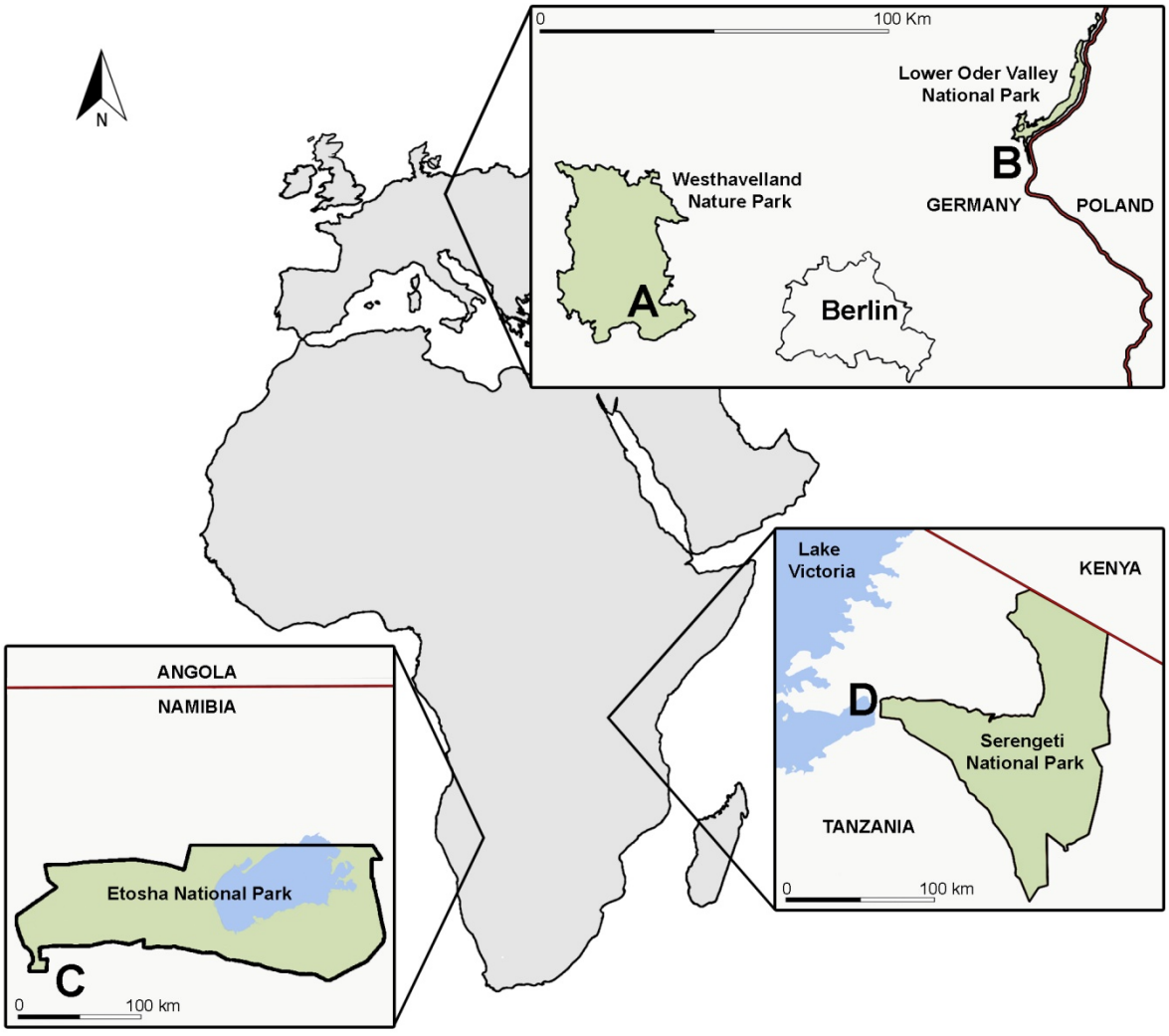

Figure 6: Location of the four study areas: Havelland (A), Lower Oder Valley (B), Etosha Region (C) and Serengeti Region (D); (figure from Rottstock et al. 2020)

2.2.1 Havelland

The study area within Westhavelland Nature Park (Havelland, Figure 7) is located about 50 kilometres west of Berlin (12.1512 E, 52.4352 N). With 131.500 ha, this nature park is the largest protected area in the federal state of Brandenburg (LfU, 2019). The landscape developed at the end of the Weichselian Glaciation (Küster, 2007). Human settlement and associated activities have led to a distinct cultural landscape (Götze, 2003). Great efforts were made to increase the potential for agricultural production during the last centuries, which led to a decline of swamplands (Siggel, 1992). These days the Havelland is characterised by a mosaic of grassland, arable land, forests, freshwater bodies and human settlements (Götze, 2003; Fiderer et al., 2019). The climate in Havelland is characterized by four seasons per year. The average annual temperature is around 9.3 ° C and the average annual rainfall is 589 mm, with most precipitation falling in the summer months (DWD, 2019a). The Westhavelland Nature Park focuses on conservation of ground nesting birds and thus comprises a range of smaller protected areas to support the implementation of the European protected area network Natura 2000 (LfU, 2019).

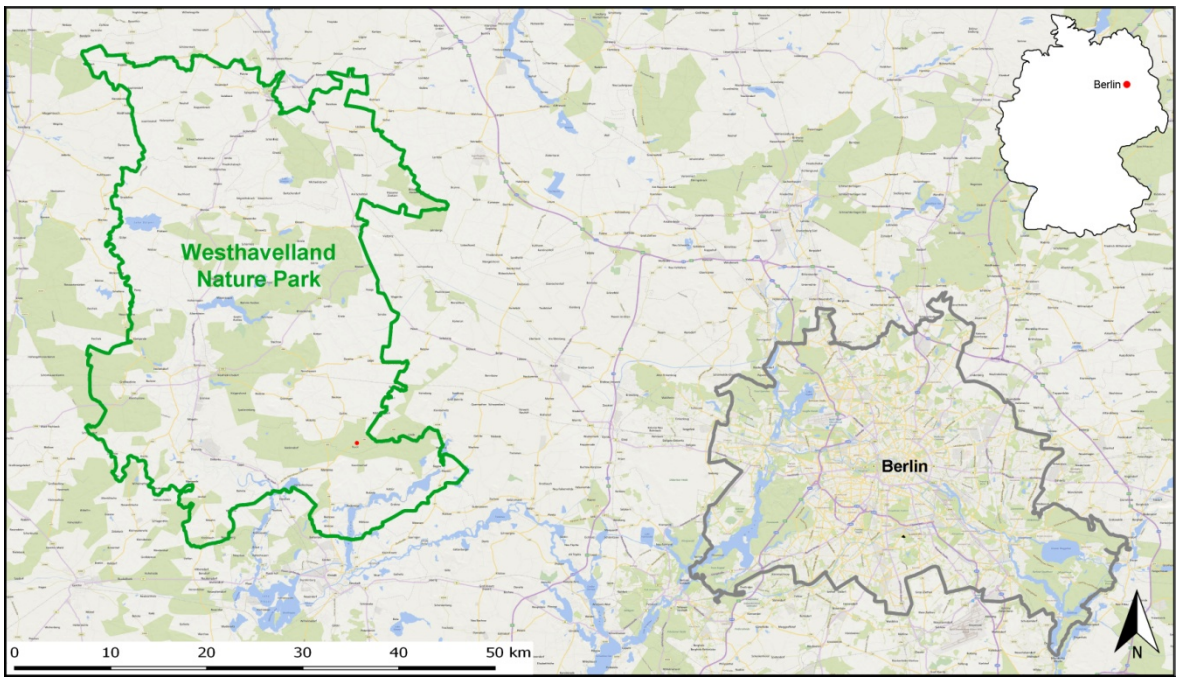

Figure 7: Location of the Westhavelland Nature Park in Germany (www.bing.com/maps)

2.2.2 Lower Oder Valley

The study area at the southern border of the Lower Oder Valley National Park (Lower Oder Valley, Figure 8) is located about 60 kilometres northeast of Berlin (14.0714 E, 52.9053 N). The national park covers 10,418 ha and is part of a trans-boundary protected area network with Poland (Vössing, 2011). Before the construction of dams, the river valley was flooded regularly (Dohle et al., 1999). Despite obvious anthropogenic influence on the area, which was shaped at the end of the last ice age (Weichselian Glaciation) a national park was founded in 1995 (Vössing, 2011). The climate in the area is characterised by four seasons of the year, with an average annual rainfall of 521 mm (most rainfall during summer month) and a mean annual temperature of 8.9°C (DWD, 2019b). The elevation of the national park is close to sea level. The vegetation of the particular fertile area is characterised by a mosaic of forests, grasslands and aquatic habitats (Vössing, 2011). Despite its high protection status, controlled grazing of livestock is commonly practiced inside this national park (Land Brandenburg, 2014). As the grasslands have developed through traditional farming practices, they depend on adequate management. The grazing systems in Lower Oder Valley can be roughly differentiated in traditional rotational grazing and "naturalistic grazing", recently introduced by conservationists. The second one is characterised by permanently low density grazing of Heck cattle (*Bos primigenius* f. taurus) and Konik horses (*Equus ferus f. caballus*) on one and the same pasture. "naturalistic grazing" is based on the idea that domesticated herbivores in part fulfil ecological functions of wild large herbivores that originally existed in this region before disappearing or even becoming extinct (Vera et al., 2006).

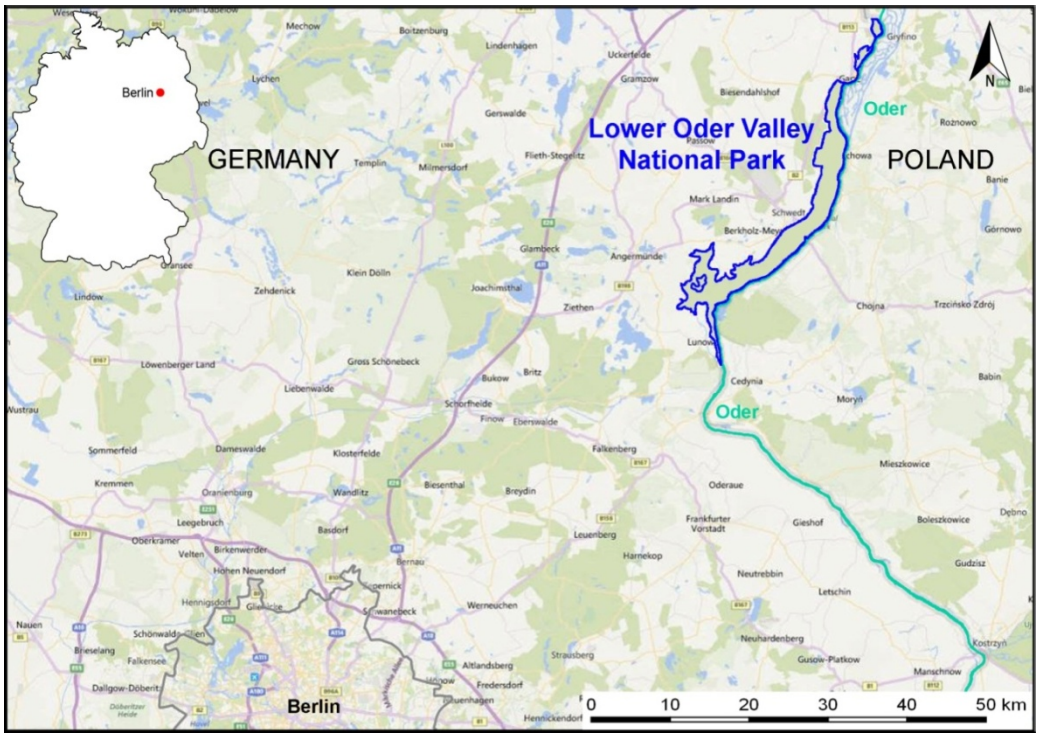

Figure 8: Location of Lower Oder Valley National Park in Germany (www.bing.com/maps)

2.2.3 Etosha Region

The study area in Namibia (Etosha Region, Figure 9) is located on commercial land at the southern border of Etosha National Park (14.9494 E, 19.6126 S). The protected area was established in 1907, comprises 22,270 km^2 and is enclosed via a high game fence nowadays (Berry, 1997). This fence aims to protect livestock on southern commercial farms and northern communal areas from transmission of diseases (Berry, 1997; Göttert and Zeller, 2008). Etosha National Park is used for eco-tourism since the middle of 20th century (Berry, 1997). Wildlife has essential value for the tourism sector, important for Namibias economy (Mendelsohn et al., 2002). The landscape developed several million years ago. It can be distinguished between sandy flat savanna woodlands (Kalahari Sandveld), areas with white limestone rocks (Karstveld) and mainly flat areas, characterized by rocks of granite and gneiss (Kamanjab plateau) (Mendelsohn et al., 2002). The semi-arid region receives average annual rainfall of only 250 to 400 mm. The average annual temperature is above 22°C. Riverbeds contain water only temporary after rainfall, which can occur sporadically in summer months (November to April) with a high inter-annual variability (Mendelsohn et al., 2002). Given unreliable rainfalls and frequent droughts, sedentary livestock farming is difficult in many parts of Namibia (Barnard et al., 1998). The relatively poor soils support only low densities of livestock (Mendelsohn et al., 2002). The vegetation in Etosha Region is characterised by mixed woodland savanna and partly open grasslands. Mopane (*Colophospermum mopane*) and Acacia species are dominating among the wooden flora.

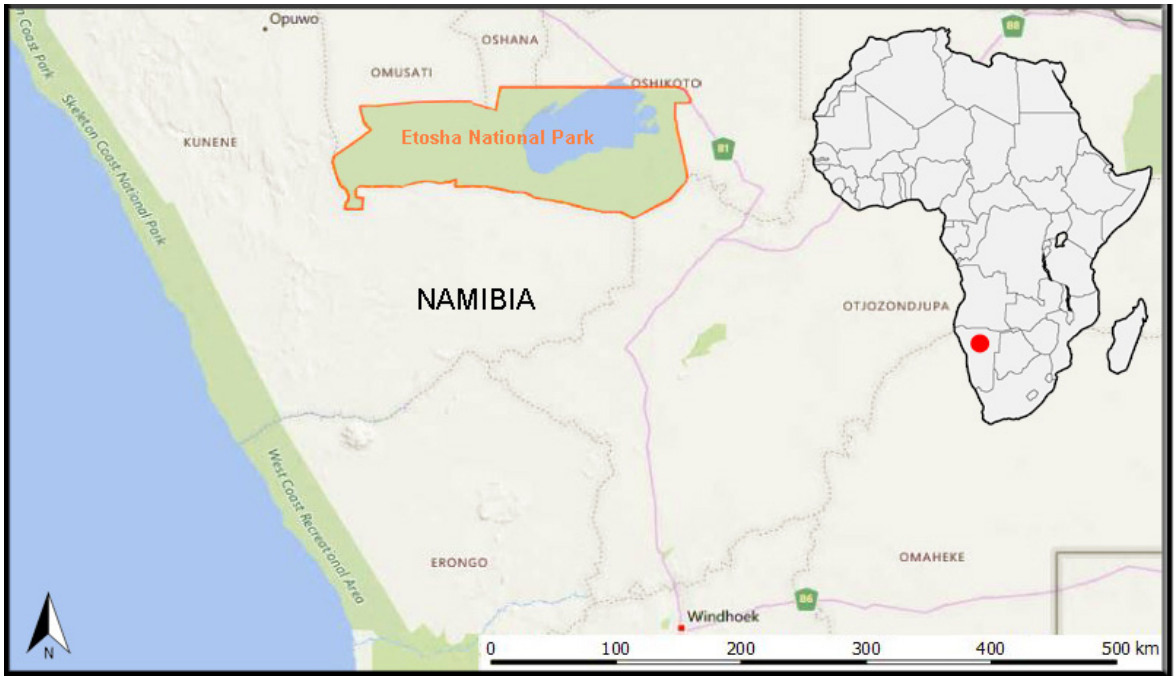

Figure 9: Location of the Etosha National Park in Namibia (www.bing.com/maps)

2.2.4 Serengeti Region

The study area in Tanzania (Serengeti Region, Figure 10) is located on communal land west of Serengeti National Park (SNP) (33.8714 E, 2.1207 S). The 14,763 km^2 measuring national park was founded in 1951 (Sinclair et al., 2008). Together with the Maasai Mara Reserve in Kenya, SNP represents the core area of the greater Serengeti-Mara Ecosystem (Olff and Hopcraft, 2008). This trans-boundary protected area network comprises several more protected areas and covers approximately 25,000 km^2 (Sinclair et al., 2008). The average maximum daily temperature ranges from 15°C in the highlands to 30°C at the shore of Lake Victoria (Sinclair et al., 2008). The semi-arid area experiences a bimodal rainfall pattern, while the precipitation is highly variable and unpredictable. Usually there are two rainy seasons (April to June and November to February). The average annual precipitation ranges from 514-688 mm in the southern plains to 972-1100 mm in the north of Serengeti (Campbell and Hofer, 1995). The vegetation of SNP is characterised by open grassland savannas, interspersed with woody vegetation (mostly *Acacia* species); most trees grow along riverbeds (Sinclair et al., 2008). The Serengeti's savannas offer essential grazing land for migrating ungulates (Holdo et al., 2009). SNP is well-known for its rich wildlife community and the world's largest remaining seasonal mass migration of naturally occurring ungulates (e.g. plains zebra [*Equus quagga*], Thomson's gazelle [*Gazella thomsonii*] and common wildebeest [*Connochaetus taurinus*]) (Dublin, 1995; Thirgood et al., 2004; Sinclair et al., 2008). Apart from nature conservation and associated eco-tourism, human activities are forbidden inside the national park (Thirgood et al., 2004; Olff and Hopcraft, 2008).

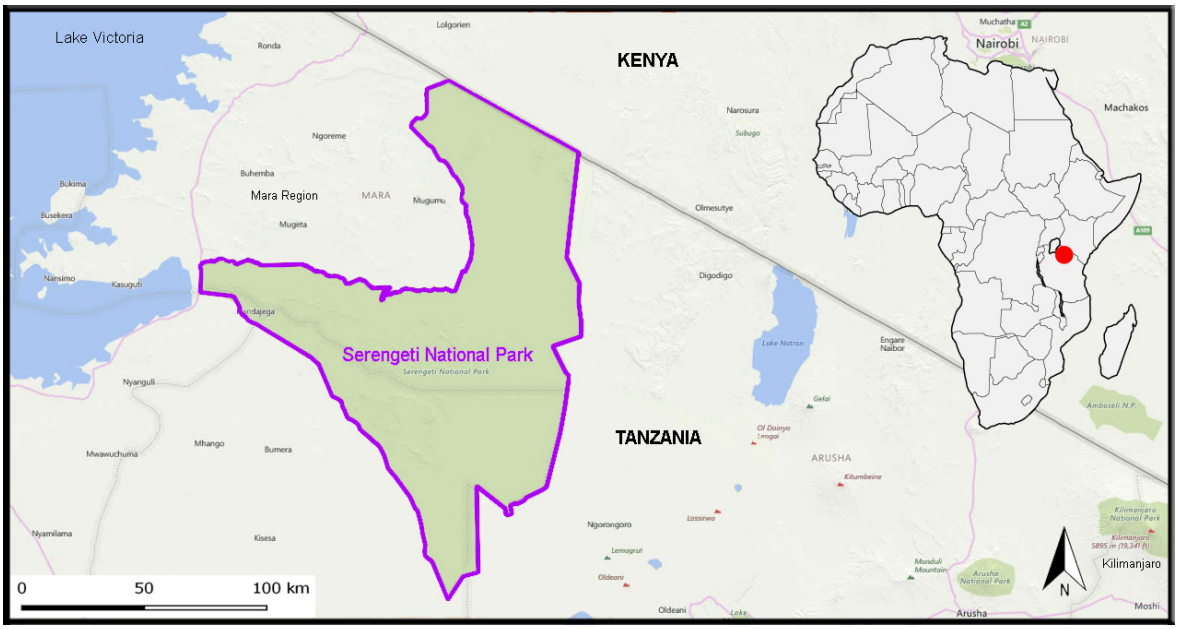

Figure 10: Location of the Serengeti National Park in Tanzania (www.bing.com/maps)

2.3 Camera trap surveys

Four comparative camera trap studies were conducted to identify common wildlife response patterns to different livestock grazing systems in central Europe and sub-Saharan Africa. For these studies, the term wildlife was defined as not domesticated carnivores and ungulates with at least four kilogram body weight. The pastures were selected so that both, a more intensively-used grazing system and a less-intensively used grazing system, were observed in Germany and sub-Saharan Africa. The grazing intensity is based on livestock stocking densities obtained from the respective livestock farmers.

Camera trapping has been used to observe wildlife for more than 100 years, but its popularity has increased recently (Cadman and Gonzales-Talaván, 2014). Camera trapping is particularly suitable to monitor medium and large sized terrestrial mammals, while the low disturbance of wildlife during data collection enables even the observation of cryptic species (O'Brien et al., 2011; Trolliet et al., 2014). Camera traps can be used to investigate diverse parameters in wildlife ecology (McCallum, 2013). Surveys from all over the globe reveal that camera trapping is suitable to study presence and activity patterns of wildlife. Thus, relative capture frequencies are commonly used. Tobler et al. (2008 and 2009) monitored multiple wildlife species by using the number of independent events per 1000 trap days to observe activity patterns and habitat use of wildlife species in Peru. O'Brien et al. (2003) compared relative capture rates (photographic events per 100 camera trap days) of tigers in Sumatra to assess the impact of human disturbance. The same index was applied for multiple-species studies in Uganda (Treves et al., 2010), Cambodia (Gray and Phan, 2011) and Thailand (Jenks et al., 2011), investigating spatial distribution, habitat use and activity patterns of wildlife. In addition to the relative capture frequency (RCF), presence and daily activity patterns of wildlife can also be analysed through percentage of photographic counts (Liu et al., 2013).

2.3.1 Data collection

For these studies, commercially available digital camera traps (Stealth Cam® G45NG PRO HD) with infrared sensor and infrared flash were deployed. In each case study, 20 of these camera traps were attached to woody vegetation at about one meter above ground (e.g. Kuijper et al., 2014; Cadman and Gonzales-Talaván, 2014). The camera trap sites were preselected based on satellite images (Ancrenaz et al., 2012). In Q-GIS defined GPS coordinates were transferred to a handheld GPS-unit (Garmin 64S, Garmin Ltd., Schaffhausen, Switzerland) to position the camera traps in the field (Figure 11).

Figure 11: Installed camera traps on rangeland in Namibia (left) and Germany (right)

After mounting the camera traps, disturbing vegetation was removed in front of the sensor (Ancrenaz et al., 2012; Cusack et al., 2015). As slight deviations were accepted in order to increase safety and accessibility (Cadman and Gonzales-Talaván, 2014), the precise camera trap positions were mapped with a mobile GPS-unit and documented in a respective data sheet (Rovero et al., 2010). A data sheet was prepared for each survey, containing information about the single camera traps, including camera number, GPS position and duration of data collection (Appendix 7.1). As a data collection of two to three months is adequate for medium-sized and large mammals (Ancrenaz et al., 2012) and the effort of the survey should at least comprise 1,000 camera trap days (O'Brien et al., 2011), a period of about ten weeks with 20 camera traps was intended for each study area. During the period of data collection, the camera traps were looked after on a weekly basis (Kuijper et al., 2014). In doing so, the SD-cards were exchanged and the battery status checked. Adjustments were made when necessary (Ancrenaz et al., 2012; Cadman and Gonzales-Talaván, 2014). In Lower Oder Valley, the setting of the camera traps was changed according to the one hour shift of daylight saving time.

2.3.1.1 The camera trap model

As the diverse technical features of the available camera trap models influence the capture probability (Swann et al., 2011; Cadman and Gonzales-Talaván, 2014; Trolliet et al., 2014), a single model (Figure 12) was used to increase comparability. This camera trap offers various advantages for the here conducted surveys, like for instance the passive infrared sensor, which is essential to capture a variety of target species with different sizes (Rovero et al., 2010; Swann et al., 2011). In addition, the fast trigger speed (< 0.5 sec) was important since the cameras were mounted at places, where the animals were likely to pass without resting (Rovero et al., 2013; Trolliet et al., 2014). Another crucial feature was the invisible infrared flash, which minimizes wildlife disturbance (Rovero et al., 2013; Trolliet et al., 2014). To mitigate the risk of theft the camera traps had to be compact and unobtrusive designed (Swann et al., 2011; Ancrenaz et al., 2012).

Figure 12: The used camera trap model - Stealth Cam G45NG PRO HD, USA

2.3.1.2 Camera trap settings

As proposed by Cadman and Gonzales-Talaván (2014) camera trap settings were made prior to the surveys in order to speed up the installation in the field. In the camera trap menu the photo mode was selected, whereby the operating hours were not limited in order to observe daily activity patterns. In Lower Oder Valley, the time settings were changed according to the one hour shift of daylight saving time. The camera sensor was set on standard (30 meter), which is similar to the range of the flashlight required for data collection during night. In order to ease the identification of the recorded species, the resolution was set to the highest available (Swann et al., 2011; Trolliet et al., 2014) and the cameras were set to produce a series of five photos each time the sensor was activated (Rovero et al., 2013; Cusack et al., 2015). A delay of 30 seconds was set after the trigger activation to save the capacity of batteries and SD-cards (e.g. Ancrenaz et al., 2012; Cadman and Gonzales-Talaván, 2014). To ease the assignment of the collected data the camera traps were designated by unique names (numbers from 1 to 20), printed on the info bar at the bottom of each photo. Also SD-Cards were marked accordingly by using a permanent marker (Cadman and Gonzales-Talaván, 2014). Finally, an electronic password was defined, so that the camera traps were not useful for someone else (Swann et al., 2011).

2.3.1.3 Sampling designs

The study areas were selected so that two grazing systems of different intensity were examined in both, Germany and sub-Saharan Africa. The intensity of land use results from the livestock stocking density obtained from the respective farmers. While less intense grazing of livestock was observed in Lower Oder Valley and Etosha region, more intense livestock grazing was looked at in Havelland and Serengeti Region (Table 2).

Table 2: Details of the observed grazing systems (table from Rottstock et al. 2020)

	Central Europe				**Sub-Saharan Africa**			
Case study	**Havelland**		**Lower Oder Valley**		**Etosha Region**		**Serengeti Region**	
Grazing system & reference site	Rotational grazing	Same pasture during livestock absence	Naturalistic grazing	Neighbouring grassland	Rotational grazing (mixed farm)	Neighbouring game farm	Agro-pastoralism during day	Same pasture during night (livestock absence)
Features of grazing system	Electrified fence	No fence	Electrified fence	No fence	Non-electrified fence	No fence	No fence, herders & dogs	No fence, livestock in bomas
Livestock kept	Cattle	No livestock	Cattle & horses	No livestock	Cattle	No livestock	Cattle, sheep & goats	No livestock
Livestock density[1] per ha	1.7	-	0.5	-	0.04	-	17	-
Degree of disturbance	More-disturbed	-	Less-disturbed	-	Less-disturbed	-	More-disturbed	-
Vegetation cover	Grass height decreasing during study period	Grass height increasing during study period	High grass layer throughout study period	Short grass layer throughout study period	Bushes & hardly any grasses throughout study period	Bushes & hardly any grasses throughout study period	Hardly any grasses throughout study period	Hardly any grasses throughout study period
Study period	07.07.-10.09.2017	07.07.-10.09.2017	16.02.-24.04.2017	16.02.-24.04.2017	20.03.-01.06.2019	15.03.-30.05.2019	25.10.-15.11.2017	25.10.-15.11.2017
Trap effort[2]	521	770	670	670	720	711	138	138
Cameras	n = 20	n = 20	n = 10	n = 10	n = 10	n = 10	n = 20	n = 20
Spacing along transects[3]	50 m	50 m	122 m	122 m	500 m	500 m	100 m	100 m

[1] Values of stocking densities are given by respective farmers

[2] Total of camera trap days

[3] Distance between camera traps

The camera traps were mounted in form of transects with uniform spacing (Foresman and Pearson, 1998). In order to take into account different site-specific conditions within the individual study areas, the spacing of the camera traps was adapted to the corresponding conditions on site. Consequently, the diverse distances between the camera traps in different study areas are an expression of the different dimensions of the observed pastures (Table 2). The intention was to map a meaningful proportion of the respective grazing systems. The spacing of the camera traps in Serengeti Region is a compromise between adequately mapping the size of the pastoral grazing system and avoiding the establishment of camera traps in vicinity of human settlements.

In order to allow for comparison of ecological parameters among the different study areas with regard to the influence of the grazing systems on the local wildlife communities, two scenarios were compared within each study area (within-site comparison). Standardised sampling designs and similar ecological site conditions improve the comparability (Ancrenaz et al., 2012; Trolliet et al., 2014). In Serengeti Region and Havelland, the difference resulted from the observation of one and the same pasture at different times. In Etosha Region and Lower Oder Valley, two pastures were compared with each other. The comparison of two scenarios within each study area was necessary, since data generated by camera traps are not directly comparable with data from another study area (Jenks et al., 2011). Thus, comparable scenarios were observed per study area in order to compare within each study area. On the basis of the within-site comparisons, ecological parameters with regard to the influence of the grazing system on the wildlife communities were compared among the four study areas.

As these comparative studies target a range of species, it should be considered that the sampling design does not fit all of them equally (e.g. Cadman and Gonzales-Talaván, 2014; Cusack et al., 2015). For instance spatial autocorrelation (recording of the same individual at several cameras) varies among different species (Ancrenaz et al., 2012).

A map was designed for each survey by using GPS-locations of the cameras to visualise the sampling design (Figure 13). If not mentioned otherwise, all presented geographical maps were made via QGIS 2.18 on the basis of satellite images provided by bing maps (www.bing.com/maps). For the visualization of the boundaries of protected areas, GIS shapes available online at www.protectedplanet.net were used. The satellite photos were also used to roughly inventorize the present land use forms.

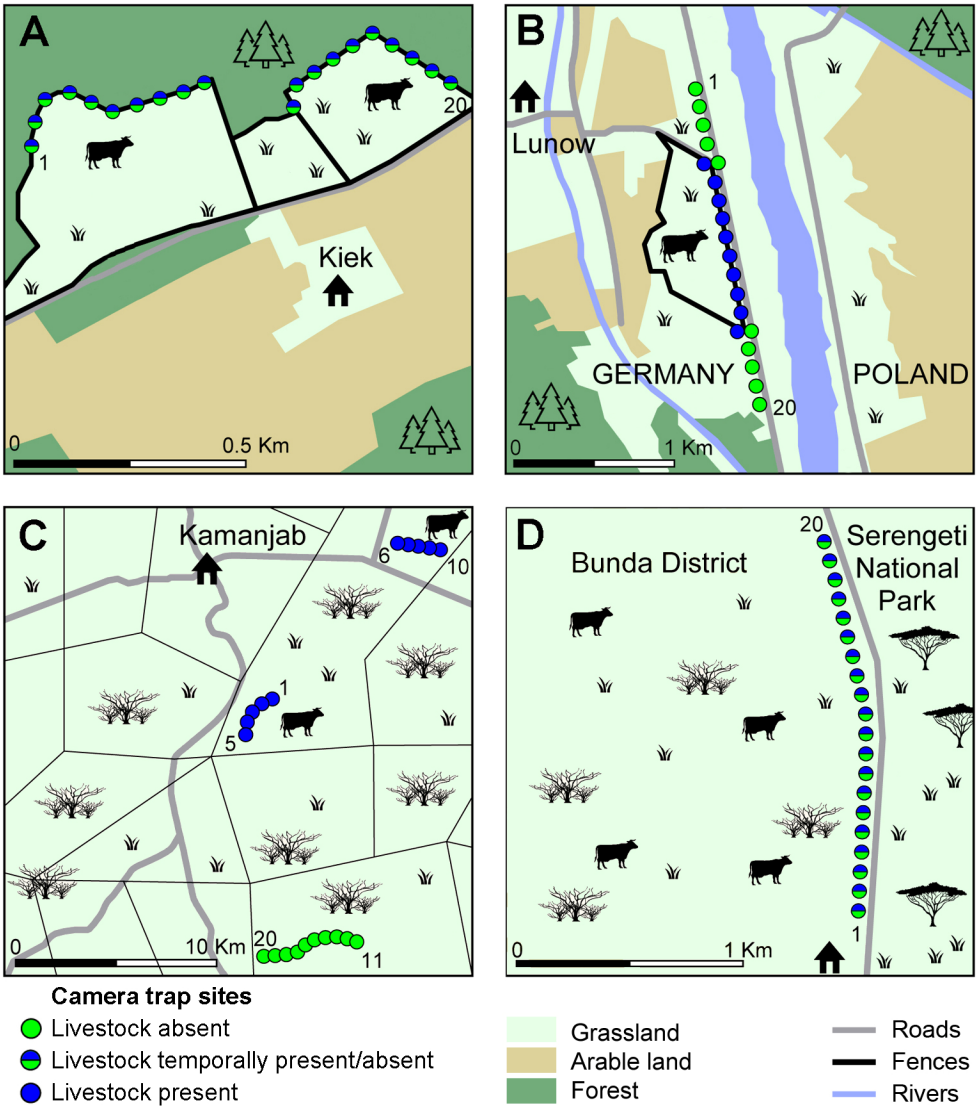

Figure 13: Camera-trap designs in the four study areas: A - Havelland, B - Lower Oder Valley, C - Etosha Region, D - Serengeti Region; (figure adapted from Rottstock et al. 2020)

Havelland

A camera trap survey was conducted in the Westhavelland Nature Park (Germany) from 7th of July until 10th of September 2017. This survey focused on rotational grazing of cattle, typical for the study area. The observed grazing land is situated in the southern part of the protected area, in Kiek (Figure 14). The approximately 30 hectare of grassland are divided into several smaller paddocks for rotational grazing of about 60 head of cattle (Angus). Twenty camera traps were mounted with an equal spacing of 50 meters along the fence line, facing towards the grazing land (Figure 14). In order to enable a detailed impact assessment of electrified fences and cattle presence on wildlife species two scenarios were comparatively analysed on the grazing land. Therefore, it was distinguished between:

Scenario 1 - grassland without presence of electric fence and livestock
Scenario 2 - grassland with presence of electric fence and livestock

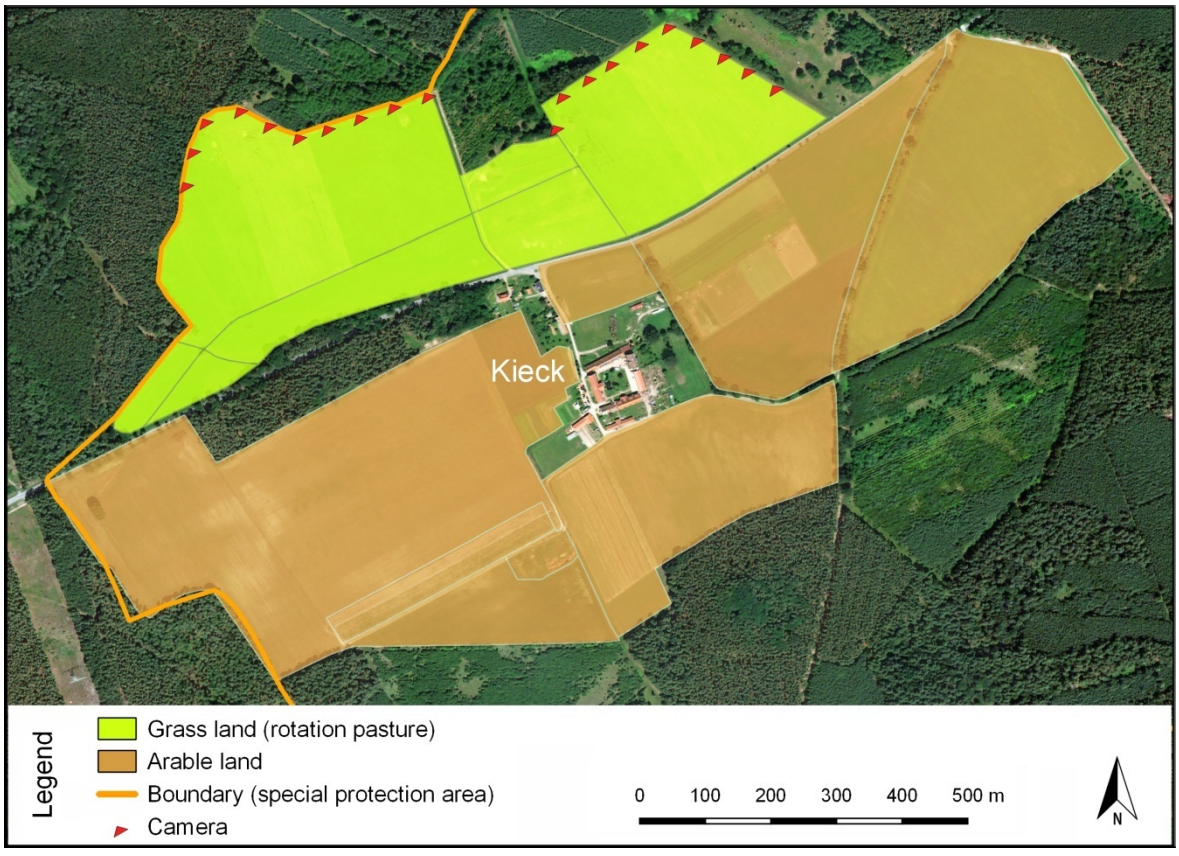

Figure 14: Sampling design of the camera trap survey in Westhavelland Nature Park (www.bing.com/maps)

Lower Oder Valley

Although local livestock grazing is traditionally restricted to the growing season and characterised through rotation, a different grazing system has been introduced by conservationists in Lower Oder Valley. Associated pastures are characterised through permanent low-density grazing, including winter months ("naturalistic grazing"). Based on the temporal use, grazing systems can be divided in permanent and rotational grazing systems (Pavlu et al., 2003). Electrified fences are part of both grazing systems but are active only in the presence of livestock. Other than in permanent pasture, rotational gazing systems do not require electric fences for most of the time (when no cattle is present). In order to observe the response of wildlife to permanent grazing of livestock and associated electrified fences twenty camera traps were set up at the southern tip of the Lower Oder Valley National Park, continuously collecting data from 16th of February to 24th of April 2017. Ten camera traps (no. 6 to 15) were placed to observe 1,100 meters of permanent pasture, while ten further camera traps (no. 1 to 5 and no. 16 to 20) simultaneously observed a similar area of bordering rotation pastures (Figure 15). The rotation pastures were not grazed during the research period and served as reference. The comparatively observed pastures mainly differed in the presence of livestock and electrified fences. The camera traps were mounted with a uniform spacing interval of 120 meters parallel to the boundary of the neighbouring national park, facing into the pastures. An exception in spacing was made at the two observed fence corners. To better observe the effect of the electrified fence on the wildlife, here two cameras were mounted at the same post, one facing into either grazing system.

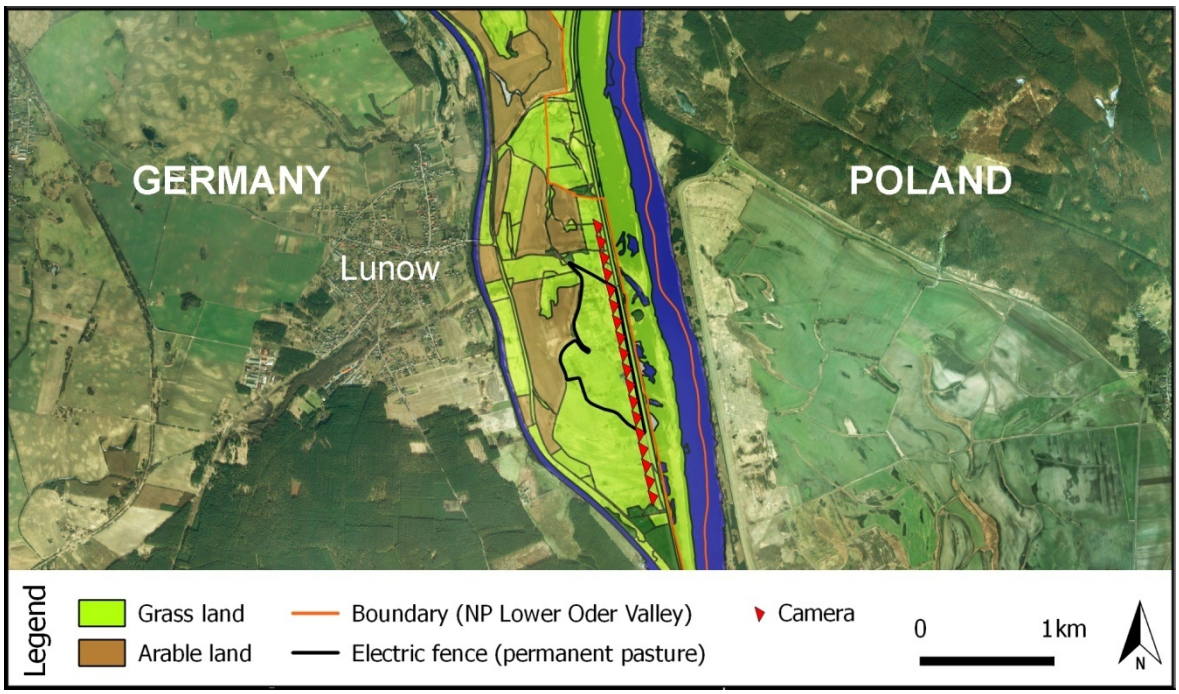

Figure 15: Sampling design of the camera trap survey at Lower Oder Valley National Park (www.bing.com/maps)

Etosha Region

A camera trap survey was conducted in Namibia, near the small town of Kamanjab (14.9494 E, 19.6126 S). Although Etosha National Park is high-fenced, a range of wildlife can be found on adjacent private farmland. The savannas south of the protected area are mostly used for commercial livestock farming and/or game farming. This survey focused on the comparative study of rangelands associated with two different farming systems; a game farm on the one hand and a mixed farm (Bonsmara cattle and wildlife) on the other hand. The data was collected from 15th of March to 1st of June 2019. 10 camera traps were installed on pastures with cattle and 10 further camera traps on a nearby game farm without livestock grazing (Figure 16). Given the large size of the pastures, a spacing of 500 meters between the single camera traps was applied. As proximity to waterholes was expected to be correlated with an increased capture frequency of wildlife, five camera traps were always installed in a line, starting at about 50 meters distance from a waterhole.

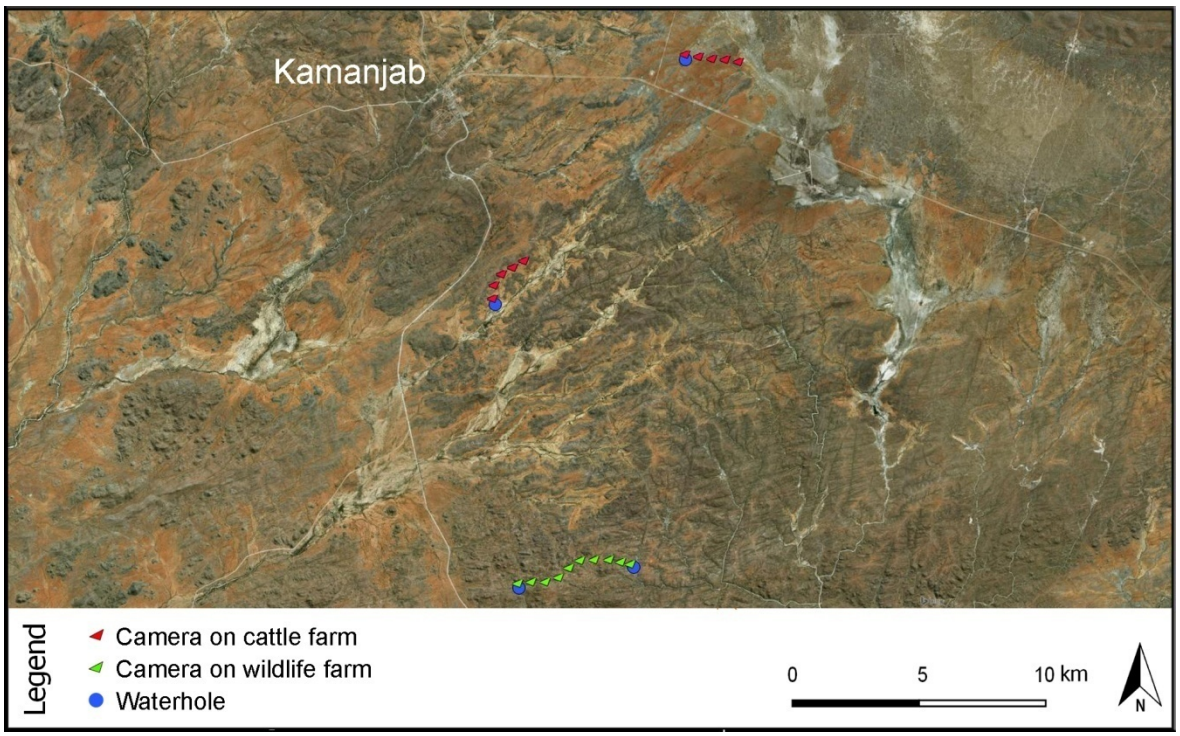

Figure 16: Sampling design of the camera trap survey south of Etosha National Park (www.bing.com/maps)

Serengeti Region

The camera trap survey in Tanzania was carried out on communally managed land between Serengeti National Park (SNP) in the East and the shore of Lake Victoria in the West (33.8714 E, 2.1207 S). The data was collected between 25th of October and 15th of November 2017. A transect of twenty camera traps was established along Sisari-Mbeya Road (B6, between Bunda and Ndabaka Gate), which marks a sharp border between two clearly different land use forms (agro-pastoralism and nature conservation). Here, 20 camera traps were arranged with a spacing of 100 meters distance between each other and all facing towards the rangeland in the west (Figure 17). Smallholder crop and livestock farming (agro-pastoralism) are the major economic activities of local communities next to the western corridor of Serengeti National Park (Sinclair et al., 2008; Mwakatobe et al., 2013). The survey was collected during the end of dry season, when overexploitation of natural resources like in particular forage was obvious and vegetative soil cover was scarce.

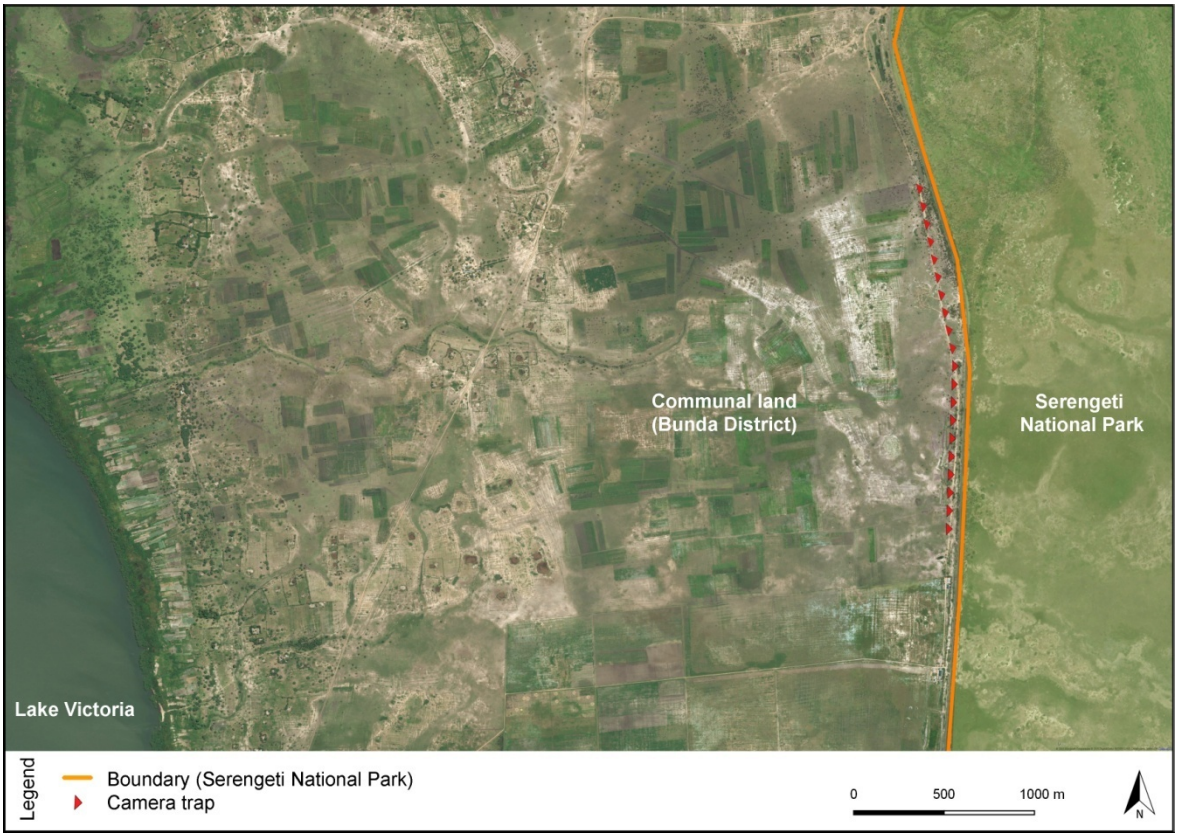

Figure 17: Sampling design of the camera trap survey at Serengeti National Park (www.bing.com/maps)

2.3.2 Data analysis

First, the photographic data was copied from the SD-cards to the hard drive of a PC for backup and structuring. (Ancrenaz et al., 2012). Pictures, which did not result from fauna were deleted immediately. The remaining files were renamed according to the date and time of capture using the software Adobe Bridge. The individual naming prevented the data from being overwritten by files with the same name (Ancrenaz et al., 2012). The files were sorted according to study area and camera trap number by creating a respective folder hierarchy (Rovero et al., 2010). In the next analysis step, a database was created for each survey. The software application “Camera Base” (MS Access) was used to organize the photographic data (Tobler et al., 2009; Rovero et al., 2010; Ancrenaz et al., 2012). The resulting spreadsheets contained information about study area, file name, camera number, species, capture date and time of all recorded photographs. This information was exported into the software Microsoft Excel and used for the final analysis of the photographic data. During these surveys, photographic counts were used to quantify capture frequencies at species level (O’Brien et al., 2003; Rovero et al., 2010). Therefore, independent events were calculated on the basis of capture date and time (Swann et al., 2011). This was done for each single camera trap at species level, while photographs of one and the same species were treated as independent events, when separated by more than five minutes (Kuijper et al., 2014). Species-specific relative capture frequencies (events per 100 trap days) were used (O’Brien et al., 2003; Rovero et al., 2010) and activity patterns for the two most often recorded species per study area constructed (Liu et al., 2013). During these camera trap studies, the following parameters associated with presence and activity patterns of wildlife (carnivores and ungulates with at least four kilogram body weight) were comparatively analysed:

2.3.2.1 Camera trap effort

The camera trap effort of each survey was determined at the beginning of the analysis by using the information from the camera trap sheets (Appendix 7.1) (Ancrenaz et al., 2012). It was calculated by summing up all days, on which the camera traps were operating (e.g. Rovero et al., 2010; Gray and Phan, 2011).

2.3.2.2 Species accumulation curve

Species accumulation curves were generated for each study area, as they are suitable to compare different situations (Thompson and Withers, 2003). The graphs show the number of recorded target species in correlation with the increasing trap effort (e.g. Thompson and Withers, 2003; Tobler et al., 2008; Rovero et al., 2010). The species-observation-curve-method was used to validate the sufficiency of study periods (e.g. Wilson, 1991).

2.3.2.3 Species richness and proportional species richness

The species richness represents the number of all recorded target species at a given site (Thompson and Withers, 2003). This biodiversity parameter was calculated to compare the influence of different grazing systems for cattle on the occurrence of wildlife, as the information can be used to assess the disturbance of wildlife by human activities (O'Brien et al., 2011).

In addition to the species richness, the proportional species richness was calculated. The proportional species richness shows the percentage of the recorded target species in relation to their total quantity known to occur in the respective study areas (Tobler et al., 2008; Treves et al., 2010; Rovero et al., 2010; O'Brien et al., 2011). The numbers of target species reported to occur in the adjacent protected areas (Appendix 7.1.1) were used as reference to judge on the species richness observed at the nearby grazing systems. Due to proximity and similar ecological conditions of the German study areas, the potentially occurring target species are the same. Consequently, the list of naturally occurring mammals from Lower Oder Valley National Park was also used for the camera trap survey in Westhavelland Nature Park. It was differentiated between the number of ungulates and carnivores in species richness and proportional species richness.

2.3.2.4 Percentage composition of wildlife communities

The percentage composition of wildlife communities ($S_{\%}$) shows the number of independent events of a particular species in relation to all independent events associated with wildlife (Liu et al., 2013). This share was compared between differently managed rangelands in Lower Oder Valley and Etosha Region or between times of presence and absence of livestock on the same rangeland in Havelland and Serengeti Region.

$$S_{\%} = \frac{100 * \sum_i^n S_i}{\sum_i^n S_i}$$

i = 1-9

n = number of camera traps

S_i = number of events of a given species at the setting i

A_i = number of events of all wildlife species at the setting i

Here it was also distinguished between ungulates and carnivores (ungulate-carnivore ratio) in order to comparatively analyse their response. The findings from each study area were visualised in a chart (Liu et al., 2013). All species names refer to the IUCN red list (IUCN, 2019). During these studies it was also looked at how many of the recorded species are listed by the IUCN as endangered, vulnerable or near threatened (Gray and Phan, 2011).

2.3.2.5 Relative capture frequency

As absolute numbers of events are not suitable to compare different situations, the relative capture frequency (RCF) was calculated at species level. This index was used to compare wildlife responses to the differently managed rangelands per study area. Here the RCF was defined as the number of independent photographic events of a given species per 100 trap days (O'Brien et al., 2003; Treves et al., 2010; Gray and Phan, 2011; Jenks et al., 2011; Ancrenaz et al., 2012).

$$RCF = \frac{100 * \sum_i^n S_i}{\sum_i^n CTD_i}$$

i = 1 - 9
n = number of camera traps
S_i = number of events of a given species at the setting i
CTD_i = number of camera trap days at the setting i

In order to evaluate wildlife responses to human activities (livestock grazing), the RCF was applied, using a method adapted from Gray and Phan (2011). The index was first calculated for each camera trap at species level by summing all independent records of a given species at a single camera trap, multiplied by 100 and divided by the number of camera trap days. The same was done for the categories of livestock and wildlife. The category of livestock included depending on the study area next to cattle also sheep, goats and horses. Photographic records of further animals were excluded from the comparative analysis. Medians of the RCFs and inter quartile range (IQR) were calculated in Microsoft® Excel 2007 for the respective groups of camera traps. The comparison of mean RCFs of wildlife among differently managed grasslands was used to assess their response to farming practices. The datasets were tested according to their distribution with the Shapiro-Wilk test. As not all data were normally distributed, the Wilcoxon signed-rank test (W-test) was applied to compare the median RCFs between differently used grassland. Furthermore, the Spearman's rank test (S-test) for correlations was applied to assess fence-effects in Lower Oder Valley and the impact of artificial water holes on wildlife behaviour in Etosha Region. Each conducted S-test is based on two examples (data sets). All statistical tests were performed with the software R 3.4.1 (R Core Team 2017). Given spatial variations in capture probability (Jenks et al., 2011) comparison of RCFs between study areas were mostly avoided. Furthermore RCFs of different target species were not compared, as the capture probability is species-specific (e.g. Treves et al., 2010; Swann et al., 2011; Sollmann et al., 2013). Here it was focused on the comparison of wildlife responses instead. The RCFs of wildlife, livestock and humans on rangelands with and without livestock presence are systematically listed in form of a table for each study area. Furthermore, absolute and RCFs are summarized (Appendix 7.1).

2.3.2.6 Temporal daily activity patterns

The wildlife response to grazing systems for livestock was also investigated in means of wildlife's temporal daily activity. Here the species-specific ratios of events associated with night and daytime were compared between pasture with livestock presence and pasture without livestock presence. Thus, the data regarding official daily sunrise and sunset (*http://galupki.de/kalender/sunmoon.php*) were used.

Additionally, the daily activity patterns were constructed for the two most often recorded wildlife species per study area. These daily activity patterns are visualised in form of graphs. The daily activity represents the share of all independent events associated with a given species recorded within two hours of the 24-hour cycle (Liu et al., 2013). Therefore, the information about the recording time of the photographs was used (McCallum, 2013). According to their recording time, the photographic events were pooled into 12 intervals of two hours each (Liu et al., 2013).

$$T_{\%} = \frac{100 * \sum_{i}^{n} S_{ij}}{\sum_{i}^{n} A_i}$$

i = 1-8
j = 1-12
n = number of camera traps
S_{ij} = number of events of a given species i in one of 12 time periods
A_i = number of events of a given species i over all time periods

2.4 Problem-centred interviews

The problem-centred interview (PCI) is particularly suitable for data collection in case study research (Witzel and Reiter, 2012). The method is used to gain information on subjective opinions and habitual activities of interviewees (Witzel, 2000). The problem centring implicates a focus on the research problem (Flick, 2006). At the same time this method is flexible enough to identify new aspects (Witzel, 2000; Witzel and Reiter, 2012). Thus, problem-centred interviews were applied in the four study areas to gain detailed information about the case-specific situation of livestock-wildlife interactions associated with the grazing of cattle.

2.4.1 Data collection

2.4.1.1 Questionnaire

After the analysis of common wildlife response patterns to livestock grazing (camera trap surveys), local grazing systems were characterised. Since this information is crucial for the understanding of the diverse situations in the four study areas, the data was collected at the beginning of the research, before the problem centred interviews. According to Witzel and Reiter (2012), a short questionnaire was developed to support the interview process (Appendix 7.2.1). Like these comparative studies, the questionnaire focuses on cattle farming and associated grazing systems. Consequently, this information was only obtained from cattle farmers as key stakeholder. It contains closed-questions in form of check-boxes to keep the following interviews more open. The cattle farmers were encouraged to hand back the filled out questionnaire prior to the interviews.

2.4.1.2 Stakeholder

As explained in chapter 1, there are various threats of agro-biodiversity associated with the grazing of cattle in central Europe and sub-Saharan Africa. Since effective management concepts require a good understanding of diverse factors (Barrows et al., 2005; ELO, 2010), this study focuses on livestock-wildlife interactions by analysing the major associated forms of land use (livestock grazing, conservation and hunting; Figure 18). Next to the already mentioned cattle farmers, further respective stakeholders were selected as interviewees in each study area. The stakeholder's motivation to participate in the survey was determined by telephone calls in advance.

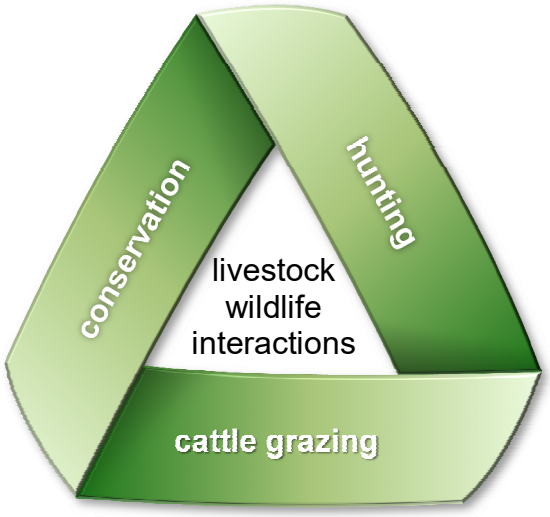

Figure 18: Observed land use forms, associated with livestock-wildlife interactions

2.4.1.3 Interview process

Stakeholders were mostly interviewed at their workplace, as the venue has impact on the responses (Witzel and Reiter, 2012). A standard text was used at the beginning of each interview to introduce oneself and the research topic. Thus, the interviewees were informed that the survey is conducted anonymously (Witzel and Reiter, 2012). As electronic recording has a number of advantages (Flick, 1991; Witzel, 2000; Meijaard et al., 2011), all interviews were recorded with a digital voice recorder (Philips Pocket Memo DPM6000). The interviewees were asked to agree on that practice beforehand. In addition to the electronic recording, written notes were taken during the interviews for later reflections of the interview process (Witzel and Reiter, 2012).

2.4.1.4 Interview guide

Since the PCI is a type of semi-structured survey (Hopf, 1991), an interview guide (Appendix 7.2.2) was used during data collection. The interview guide supports the comparative analysis of different cases (Witzel, 2000; Witzel and Reiter, 2012). The used interview guide covers the three land use forms, associated with livestock-wildlife interactions (cattle grazing, conservation and hunting; Figure 18). Depending on the background of the stakeholder, he/she could tell more about the one or the other topic. The interview guide contains exclusively open questions, aiming to encourage the interviewees for narratives. During the interviews, the questions were not asked in a certain order, but rather strategically, to keep the conversation casual and to assure that all important aspects were covered (Witzel, 2000; Witzel and Reiter, 2012).

2.4.2 Data analysis

According to Witzel and Reiter (2012) the analysis of the collected data was done in three steps (transcription, detailed analysis and systematic comparison) for each single study area. Afterwards a cross-case analysis was applied in order to identify common patterns and general valid relations between the study areas (Witzel and Reiter, 2012; Yin, 2014).

2.4.2.1 Transcription

The analysis of the collected interview recordings stated with their transcription (Witzel, 2000). For transcription of the recorded audio files and structuring of the resulting text, the software MAXQDA was used (Kuckartz, 2007; Lewins and Silver, 2007). Interviews, recorded in German and Swahili were translated into English. The analysis focused on the content and not on the exact wording of the interviews. According to Witzel and Reiter (2012) aspects, particularly relevant for the research problem were transcribed more detailed, than those passages with background information. Text passages with similar meaning were summarized to reduce the amount of data (Flick, 1991).

2.4.2.2 Detailed analysis

During the second analysis step, the transcribed data was structured and further condensed through coding (Ridder, 2016). A code list (Table 3) was developed and text passages from the interviews were grouped in categories according to their meaning to identify relationships between evolving themes (Corbin and Strauss, 2008). For example, the code “wildlife disturbance” was applied to condense statements of respondents that refer to the impact of cattle farming on the presence and activity patterns of wildlife species. The orientation on the research questions ensured the problem centring and facilitated a comparative analysis (Witzel and Reiter, 2012). However, since the development of new concepts requires certain openness some codes also base on interview data (e.g. Witzel and Reiter, 2012; Ridder, 2016). The coding resulted in a list for each single case study, comprising statements of all respective interviewees.

Table 3: Code list - structuring of the interview data

Category	Definition
Functions / relations	Stakeholders interest in livestock farming, wildlife conservation and hunting
HWC	Major existing human-wildlife conflicts associated with cattle farming and their reasons
Livestock predation	Practices with potential to mitigate predation of cattle by large carnivores
Ecological sustainability	Practices with potential to mitigate land degradation through overgrazing by cattle
Wildlife disturbance	Impact of livestock farming on wildlife presence and activity

2.4.2.3 Systematic comparison

The third analysis step was conducted according to „Grounded Theory“ (Corbin and Strauss, 2008), to comparatively analyse the interviews associated with the same study area. The condensed and structured interview data was used to identify common patterns and differences in the stakeholder’s statements. The share of respondents with similar attitudes towards a certain theme was calculated and used to explain the specific situation in the study area. Selected statements from the interviews are presented under each of the findings. For better understanding, main findings of the problem-centred interviews from each study area are visualised via a flowchart (Flick, 1991), which explains the major regional HWC and the associated relationships. This analysis step results in a description of the case-specific findings as basis for the following cross-case comparison.

2.4.2.4 Cross-case analysis

As it was attempted to identify common patterns among the four studied areas in central Europe and sub-Saharan Africa, a cross-case comparison was applied in reference to Ridder (2016). During this final analysis step, findings from the different study areas were compared to identify common patterns and differences. The key information associated with the single codes was inserted into tables to identify common patterns between the studied areas as well as case-specific features. In doing so it was also looked for relationships between the before identified patterns. Findings from the different study areas were organised in tables for transregional comparison (Ridder, 2016).

The questionnaire data was comparatively analysed among the four study areas. The cattle farmer’s responses were grouped for each of the considered parameters per study area. Appendix 7.2.6 shows the basic farm parameters. The respective medians and interquartile range (IQR) were calculated in Microsoft® Excel 2007. On this basis a box-plot diagram was produced for each of these parameters, which commonly shows the results from the four study areas. The questionnaire data was used to identify the case-specific structure and motives of cattle farming as well as preferred characteristics of cattle breeds.

For comparison of the respondents’ functions, their interest in each of the three land use forms associated with livestock-wildlife interactions (cattle grazing, hunting, wildlife conservation) was evaluated, by using a four-step ranking (Appendix 7.2.5). Thus, the interest of single respondents in each of the three land use forms was assessed with a value from 0 to 3. Furthermore, for each of the three land use forms, a focal group was defined by a maximum interest (value of 3) in the focus land use form and not more than value of one in the other land use forms. The finding is visualised via a 3D-diagram, comprising all 43 interviewees from the four study areas.

3 Results

3.1 Camera trap surveys

3.1.1 Camera trap effort and species accumulation curves

In three out of four study areas, the total trap effort ranges from 1,291 camera trap days (Havelland) to 1,431 camera trap days (Etosha Region). The total trap effort in Serengeti Region is about five times lower. The livestock-presence-absence-ratio of camera trap days varies between 1:1 and 3:2 (Table 4).

Table 4: Camera trap effort spent in the four study areas

Study area	Camera trap effort Total	Camera trap effort Livestock absent	Camera trap effort Livestock present
Havelland (HVL)	1,291 (n=20)	770 (n=20)	521 n=(20)
Lower Oder Valley (LOV)	1,340 (n=20)	670 (n=10)	670 n=(10)
Etosha Region (NAM)	1,431 (n=20)	711 (n=10)	720 n=(10)
Serengeti Region (TZ)	276 (n=17)	276 (n=17)	276 n=(17)

Except the species accumulation curve from Serengeti Region, all curves plateau (LOV at 15%, HVL at 50% and NAM at 65%) (Figure 19).

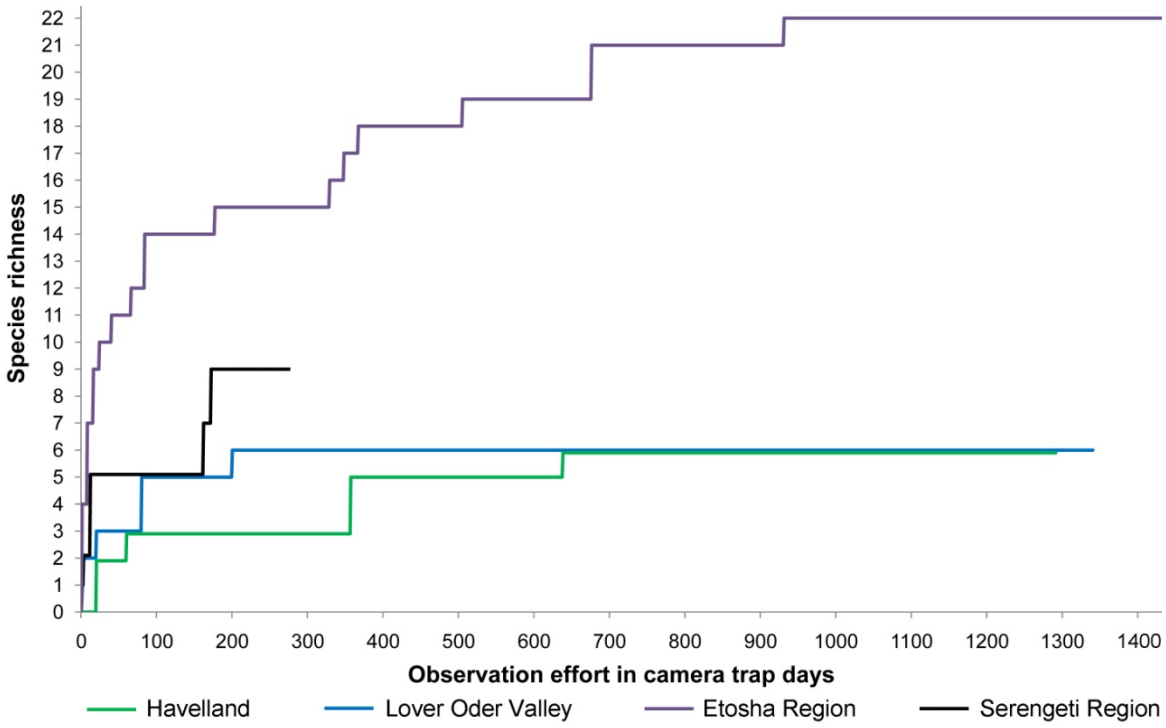

Figure 19: Increase of species richness with cumulative number of camera trap days in Havelland (n=20), Lower Oder Valley (n=20), Etosha Region (n=20) and Serengeti Region (n=17); (figure from Rottstock et al. 2020)

3.1.2 Wildlife community responses

Regardless the study area and the grazing system, the results reveal that grazing of livestock has several effects on wildlife communities (Table 5). When looking at the relative capture frequencies of total wildlife, livestock presence was associated with significantly (LOV, NAM) or highly significantly (HVL, TZ) reduced RCFs of total wildlife in all four study areas (Table 5). Further, the observed species richness (SR) of wildlife, varied between 22% in Serengeti Region and 61% in Etosha Region of the potential species richness. The presence of livestock was associated with a reduction of wildlife SR on the pastures in Serengeti Region (100%), Havelland (50%) and Etosha Region (10.5%), but not on the pasture in Lower Oder Valley (Table 5). Additionally, the presence of livestock was associated with a significant or highly significant reduction in the relative capture frequencies of total wildlife on the pastures in all four study areas (Table 5).

Table 5: Response of wildlife communities to livestock grazing in four case studies (species richness [SR], ungulate-carnivore ratio of SR and events, relative capture frequency [RCF] of total wildlife); (table from Rottstock et al. 2020)

Study area	Havelland	Lower Oder Valley	Etosha Region	Serengeti Region
Potential SR	13	13	31	41
Observed SR livestock absent	6 (46%)	6 (46%)	19 (61%)	9 (22%)
Observed SR livestock present	3 (23%)	6 (46%)	17 (55%)	0 (0%)
RCF wildlife (total) livestock absent/present **W-value; p-value**	55.1 / 27.9 294; 0.01	63.4 / 17.2 11.5; <0.01	154.61 / 51.39 18; 0.02	5.0 / 0.0 85; <0.01
Potential ratio SR (%) ungulate/carnivore	46 / 54	46 / 54	61 / 39	63 / 37
Observed ratio SR (%) livestock absent ungulate/carnivore	50 / 50	33 / 66	63 / 37	22 / 78
Observed ratio SR (%) livestock present ungulate/carnivore	33 / 66	33 / 66	65 / 35	-
Observed ratio events (%) livestock absent ungulate/carnivore	84 / 16	69 / 31	93 / 7	6 / 94
Observed ratio events (%) livestock present ungulate/carnivore	25 /75	62 / 38	86 / 14	-

When comparing the ratio of events from ungulates and carnivores, the ungulates represent the dominant fraction in the two German study areas and in Etosha Region on pasture when/where livestock is absent. Here the observed ungulate-carnivore ratio based on SR resembled the potential ratio. In contrast to Etosha Region, carnivores constitute the dominant fraction (7 out of 9 observed species are carnivores) on pasture when livestock was absent in Serengeti Region. Livestock presence had an effect on the observed ungulate-carnivore ratio (SR) in two study areas: Livestock presence causes a shift in the ratio of events towards carnivores in Havelland and no wildlife observations in Serengeti Region (Figure 20, Table 5). A similar effect is also obvious when looking at the guild-specific proportion of events (percentage of events of a guild in relation to all wildlife events [Figure 21, Table 5]).

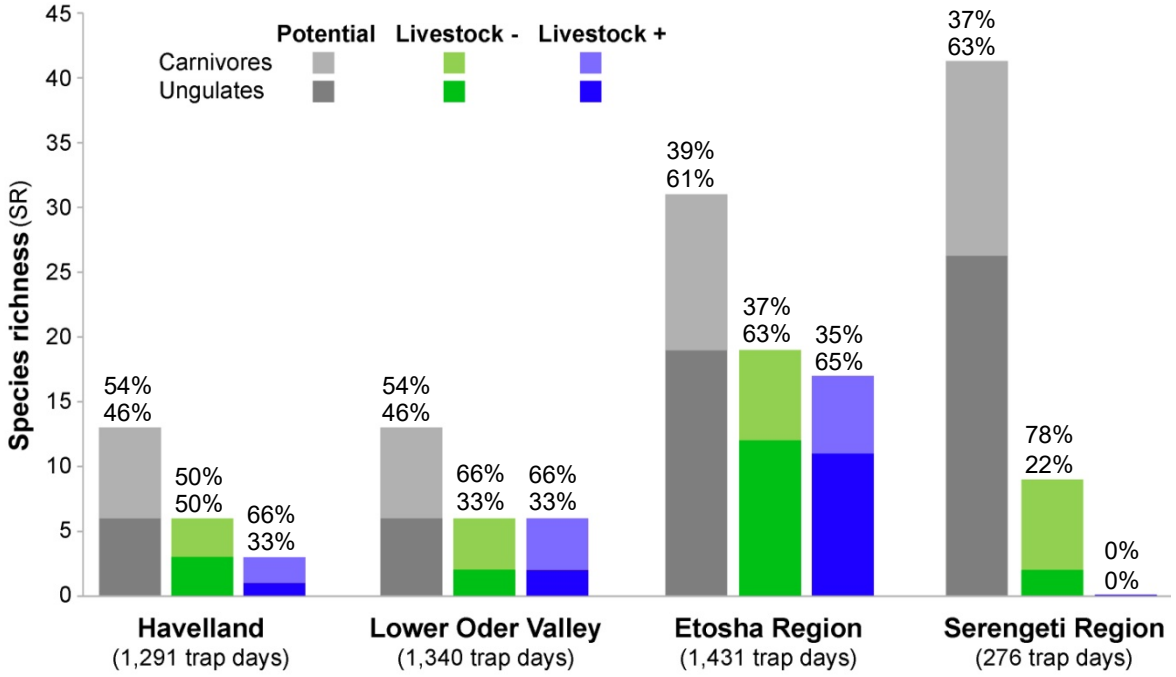

Figure 20: Potential species richness and recorded species richness on pastures with and without livestock presence in the four study areas, divided into proportions of ungulates and carnivores (figure from Rottstock et al. 2020)

3.1.3 Species-specific wildlife responses

Next to effects on wildlife communities, species-specific response to livestock grazing could be observed. The findings reveal more and less pronounced changes in the percentage of events of a particular species in relation to all events associated with wildlife (Figure 21). During livestock absence, the species-specific proportion of events (percentage of events of a particular species in relation to all wildlife events) shows a clear dominance of the roe deer (*Capreolus capreolus*) followed by the red fox (*Vulpes vulpes*) in both study areas in Germany (Figure 21). However, in both German study areas, livestock presence is associated with a reduction in relative events of the roe deer and an increase in relative red fox events. This causes a reversal of the relation between both species in Havelland but not in Lower Oder Valley.

Whether the observed rangelands in Etosha Region were associated with livestock or not, species-specific proportions of events are the highest for gemsbok (*Oryx gazella*) and mountain zebra (*Equus zebra*). Unlike the gemsbok, the mountain zebra reveals a smaller proportion of events associated with wildlife on the mixed farm when compared to the game farm. The dominating carnivore species on both farms is the black-backed jackal (*Canis mesomelas*). The black-backed jackal reveals higher levels of proportional events on rangelands with livestock presence compared to rangeland without livestock. In Serengeti Region the species-specific proportion of events is highest for the side-striped jackal (*Canis adustus*).

In contrast to the study areas in sub-Saharan Africa, no large carnivores were recorded during the camera trap surveys in Germany. However, a common feature of all study areas is that medium-sized canids represent the fraction of the most frequently observed carnivore species.

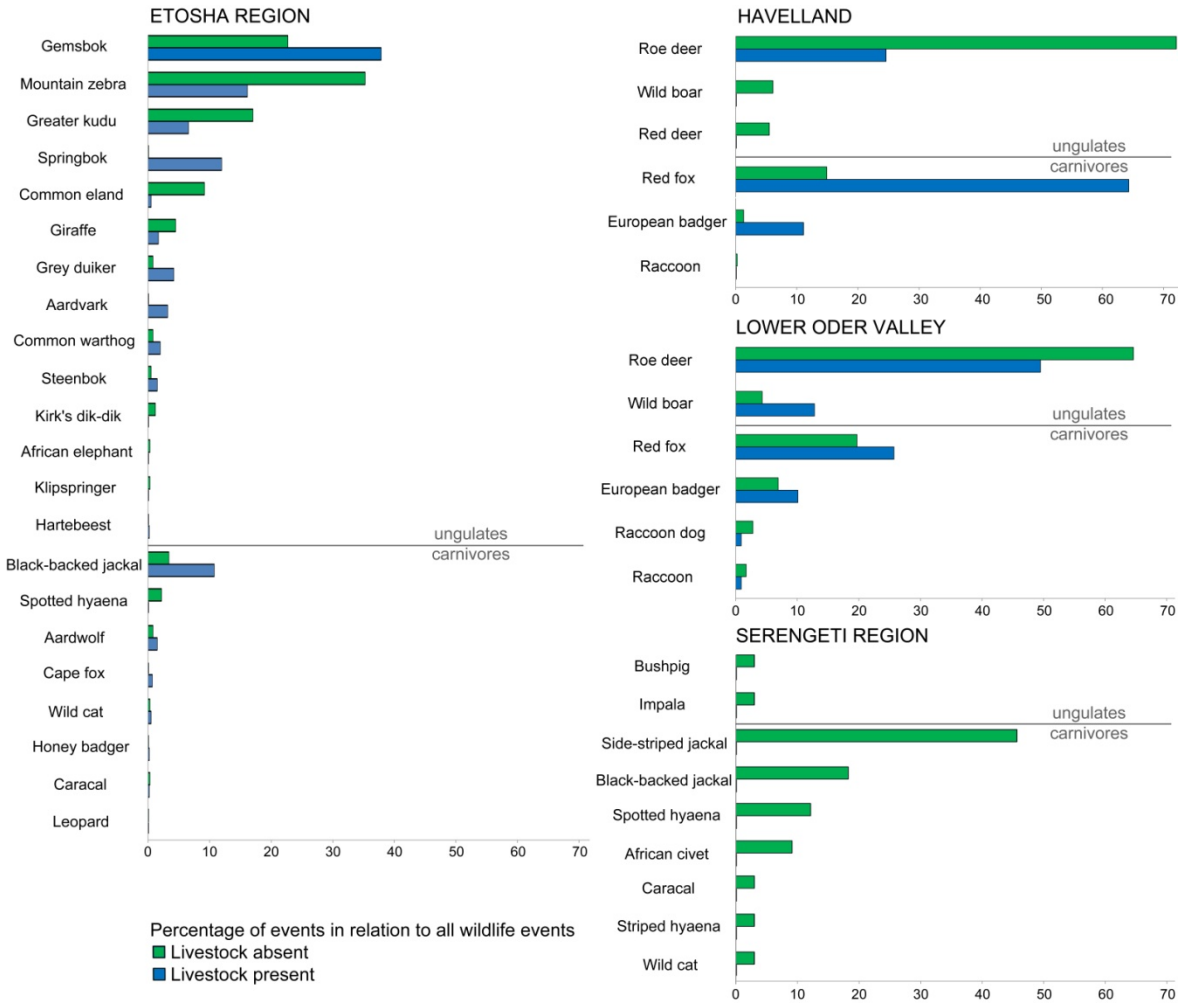

Figure 21: Percentage of events per wildlife species in relation to all wildlife events in the four single study areas (figure from Rottstock et al., 2020)

Species-specific response of wildlife can also be found when looking at the relative capture frequency (RCF). In Havelland, presence of cattle was associated with highly significantly reduced RCFs of all three recorded ungulate species (Table 6). In contrast, the recorded carnivore species show no significant response in terms of RCF. However, the carnivore species red fox (*Vulpes vulpes*) and European badger (*Meles meles*) reveal a tendency to higher levels of RCF when cattle is present on pasture in Havelland (Table 6). Here the RCF of cattle (513.7 events / 100 trap days) is about 18 times as high as the RCF of wildlife (27.9 events / 100 trap days) during the time of cattle grazing. The human activity was highly significantly increased during cattle presence on pasture in Havelland ($W=63$; $p<0.01$).

Table 6: Capture frequencies per 100 trap days for recorded wildlife, livestock and humans on pasture with (521 trap days) and without livestock (770 trap days) in Havelland (table from Rottstock et al. 2020)

HAVELLAND	**Median** (IQR) n=20		**W-value**	**p-value**
Recorded wildlife species	**Cattle absent**	**Cattle present**		
European badger (*Meles meles*)	**0.0** (2.5)	**0.0** (3.3)	180	0.54
Raccoon (*Procyon lotor*)	**0.0** (0.0)	**0.0** (0.0)	210	0.34
Red fox (*Vulpes vulpes*)	**13.0** (6.1)	**17.4** (22.6)	174.5	0.49
Red deer (*Cervus elaphus*)	**0.0** (6.0)	**0.0** (0.0)	280	**<0.01**
Roe deer (*Capreolus capreolus*)	**35.0** (48.4)	**3.6** (14.9)	312	**<0.01**
Wild boar (*Sus scrofa*)	**0.0** (5.1)	**0.0** (0.0)	290	**<0.01**
Wildlife total	**55.1** (49.5)	**27.9** (25.7)	294	**0.01**
Cattle (*Bos primigenius* f. taurus)	-	**513.7** (379.0)	-	-
Human (*Homo sapiens*)	**4.0** (7.9)	**45.5** (175.4)	63	**<0.01**

An identical assemblage of wildlife species was observed on the two neighbouring grazing systems in the Lower Oder Valley. Here all six recorded wildlife species, similarly reveal lower levels of RCF in association with livestock presence (Table 7). However, only the roe deer shows a significant difference (W=16; p=0.01). The level of RCF associated with livestock (60.4 events / 100 trap days) is almost four times as high as the RCF of wildlife (17.2 events / 100 trap days) on the observed permanent pasture. Like in Havelland, there was highly significant more human activity during the presence of livestock in Lower Oder Valley (W=25; p=0.01).

Table 7: Capture frequencies per 100 trap days for wildlife, livestock and humans on pasture with (670 trap days) and without livestock presence (670 trap days) in Lower Oder Valley (table from Rottstock et al. 2020)

LOWER ODER VALLEY	**Median** (IQR) n=10		**W-value**	**p-value**
Recorded wildlife species	**Livestock absent**	**Livestock present**		
European Badger (*Meles meles*)	**1.5** (3.8)	**0.0** (1.5)	34.5	0.23
Raccoon (*Procyon lotor*)	**0.7** (1.5)	**0.0** (0.0)	29	0.05
Raccoon dog (*Nyctereutes procyonoides*)	**0.0** (1.5)	**0.0** (0.0)	34	0.12
Red fox (*Vulpes vulpes*)	**8.2**(10.5)	**2.2** (7.8)	34	0.23
Roe deer (*Capreolus capreolus*)	**47.8** (46.6)	**5.2** (11.2)	16	**0.01**
Wild boar (*Sus scrofa*)	**3.0** (1.5)	**1.5** (1.1)	36	0.29
Wildlife total	**63.4** (68.0)	**17.2** (17.2)	11.5	**<0.01**
Cattle (*Bos primigenius* f. taurus)	-	**44.0** (24.6)	-	-
Horse (*Equus ferus* f. caballus)	-	**18.7** (6.7)	-	-
Livestock total	-	**60.4** (28.4)	-	-
Human (*Homo sapiens*)	**0.7** (3.0)	**0.0** (0.0)	25	**0.01**

The sampling design in the LOV allowed an impact assessment of electrified fences on wildlife behaviour (fence effect). There is a significant relation between the proximity to electrified fences (associated with permanent pasture) and the RCF of wildlife on the neighbouring rotation pastures (Table 8). While roe deer, red fox and European badger reveal significant to highly significant decrease in RCF values with increasing proximity to electrified fences, this effect could not be observed for the remaining species.

Table 8: Correlation of RCF of wildlife and proximity to electrified fences in Lower Oder Valley

Detected wildlife species	**Spearman's rank test**	**s-value**	**p-value**
European Badger (*Meles meles*)		56.73	**0.04**
Raccoon (*Procyon lotor*)		138.64	0.66
Raccoon dog (*Nyctereutes procyonoides*)		158.11	0.9
Red fox (*Vulpes vulpes*)		34.62	**<0.01**
Roe deer (*Capreolus capreolus*)		34.2	**0.03**
Wild boar (*Sus scrofa*)		165	1
Wildlife total		39.08	**0.01**

This species-specificity in the response-behaviour (RCF) towards electrified fence is illustrated, using roe deer and wild boar (*Sus scrofa*) as examples (Figure 22). While the pattern of wild boar observation frequency (RCF) does not alter in relation to proximity to the electrified fence sections, the roe deer shows a pronounced reduction in RCF values in response to the electrified fence.

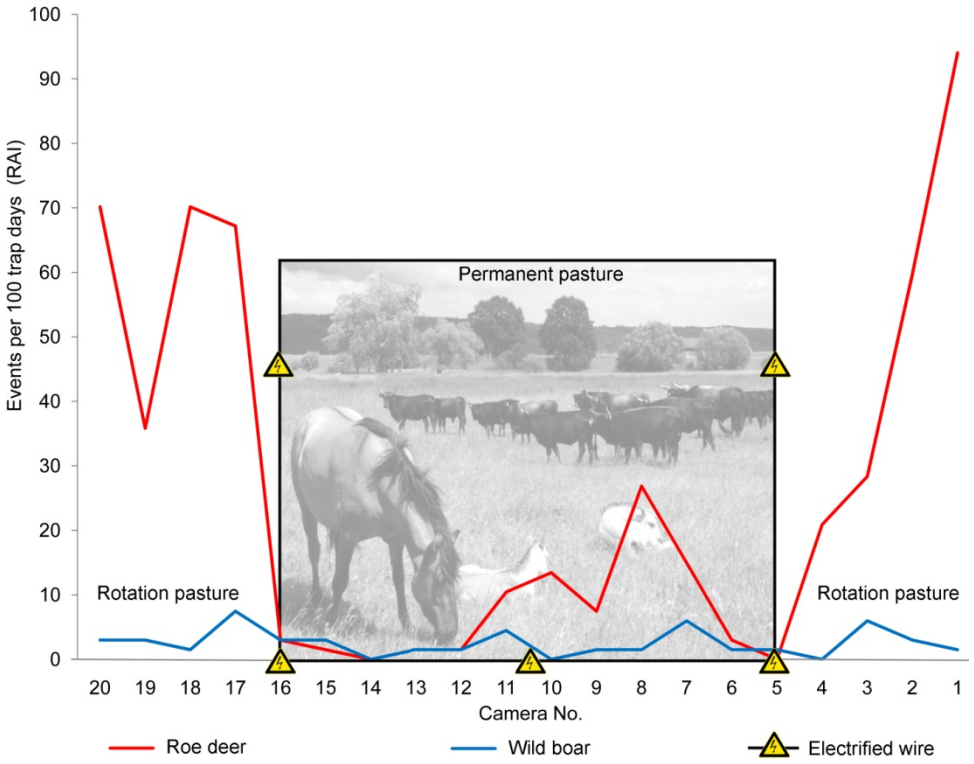

Figure 22: Relative capture frequencies of roe deer and wild boar at the single camera traps on neighbouring grazing systems in Lower Oder Valley (n=20 camera traps)

In Etosha Region, six wildlife species (common eland [*Tragelaphus oryx*], giraffe [*Giraffa camelopardalis*], greater kudu [*Tragelaphus strepsiceros*], Kirk's dik-dik [*Madoqua kirkii*], mountain zebra [*Equus zebra*] and spotted hyena [*Crocuta crocuta*]) reveal significantly to highly significantly lower levels of RCF on the mixed farm when compared to the neighbouring game farm (Table 9). In contrast, two species (aardvark [*Orycteropus afer*] and springbok [*Antidorcas marsupialis*]) reveal significantly lower levels of RCF on the game farm than on the mixed farm. On the mixed farm, the RCF level of cattle (8.33 events / 100 trap days) is about six times as high as the RCF level associated with wildlife (51.39 events / 100 trap days). Here, cattle farming tends to be linked to lower RCF of large ungulate species (common eland, giraffe, greater kudu, mountain zebra, gemsbok) and higher RCF levels of small ungulate species (grey duiker [*Sylvicapra grimmia*], springbok, steenbok [*Raphicerus campestris*]). In Etosha region, two large carnivores (leopard [*Panthera pardus*] and spotted hyena) were recorded. However, there observations were rare and limited to the game farm. There is no significant difference in the human activity between the two farming systems. The associated RCF was relatively low on both observed pastures (Table 9).

Table 9: Capture frequencies per 100 trap days for recorded wildlife, cattle and humans on pasture with (720 trap days) and without livestock presence (711 trap days) in Etosha Region (table from Rottstock et al. 2020)

ETOSHA REGION	**Median** (IQR) n=10		**W-value**	**p-value**
Recorded wildlife species	**game farm**	**mixed farm**		
Aardwolf (*Proteles cristata*)	**1.32** (2.38)	**0.00** (1.39)	40	0.44
Black-backed jackal (*Canis mesomelas*)	**2.63** (4.43)	**5.56** (7.29)	60.5	0.44
Cape fox (*Vulpes chama*)	**-**	**0.00** (1.04)	65	0.08
Caracal (*Felis caracal*)	**0.00** (0.99)	**0.00** (0.00)	40.5	0.33
Honey badger (*Mellivora capensis*)	**0.00** (0.00)	**0.00** (0.00)	49.5	1
Leopard (*Panthera pardus*)	**0.00** (0.00)	**-**	45	0.37
Spotted hyaena (*Crocuta crocuta*)	**1.97** (3.29)	**-**	10	**<0.01**
Wild cat (*Felis silvestris*)	**0.00** (0.00)	**0.00** (0.00)	48	0.87
Aardvark (*Orycteropus afer*)	**-**	**0.69** (1.39)	75	**0.01**
African elephant (*Loxodonta africana*)	**0.00** (0.00)	**-**	40	0.17
Common eland (*Tragelaphus oryx*)	**3.95** (9.54)	**0.00** (0.00)	14	**<0.01**
Common warthog (*Phacochoerus africanus*)	**0.66** (2.75)	**0.00** (2.43)	44	0.65
Gemsbok (*Oryx gazella*)	**52.63** (41.46)	**19.44** (15.63)	26	0.08
Giraffe (*Giraffa camelopardalis*)	**4.61** (7.68)	**0.69** (1.39)	15.5	**<0.01**
Greater kudu (*Tragelaphus strepsiceros*)	**20.18** (19.41)	**2.08** (2.78)	18	**0.02**
Grey duiker (*Sylvicapra grimmia*)	**0.00** (1.90)	**0.00** (2.43)	51	0.97
Hartebeest (*Alcelaphus buselaphus*)	**-**	**0.00** (0.00)	55	0.368
Kirk's dik-dik (*Madoqua kirkii*)	**0.00** (4.028)	**-**	30	**0.03**
Klipspringer (*Oreotragus oreotragus*)	**0.00** (0.00)	**-**	45	0.37
Mountain zebra (*Equus zebra*)	**30.26** (59.87)	**2.78** (21.53)	14.5	**<0.01**
Springbok (*Antidorcas marsupialis*)	**0.00** (0.00)	**2.08** (13.19)	72.5	**0.04**
Steenbok (*Raphicerus campestris*)	**0.00** (0.00)	**0.00** (2.08)	55	0.65
Wildlife total	**154.61** (120.07)	**51.39** (38.89)	18	**0.02**
Cattle (*Bos primigenius* f. taurus)	-	**8.33** (10.42)	-	-
Human (*Homo sapiens*)	**0.00** (6.99)	**0.00** (1.39)	42	0.52

The sampling design in NAM allowed for impact assessment of artificial waterholes on wildlife behaviour (Figure 23). In contrast to the mixed cattle/wildlife farm, the game farm reveals significant influence of waterholes on the RCF of wildlife (total). Four large ungulate species (common eland, giraffe, greater kudu and mountain zebra) show a significant increase in RCF with proximity to waterholes on the game farm (Table 10).

Table 10: Correlation of RCFs from wildlife species and proximity to water on two farms in Namibia

Detected wildlife species	game farm		cattle/wildlife farm	
	s-value	p-value	s-value	p-value
Aardwolf (*Proteles cristata*)	131.36	0.57	118.88	0.43
Black-backed jackal (*Canis mesomelas*)	152.62	0.84	165	1
Cape fox (*Vulpes chama*)	-	-	114.08	0.39
Caracal (*Felis caracal*)	127.34	0.53	165	1
Honey badger (*Mellivora capensis*)	242.78	0.17	203.89	0.51
Leopard (*Panthera pardus*)	87.22	0.17	-	-
Spotted hyaena (*Crocuta crocuta*)	260.17	0.08	-	-
Wild cat (*Felis silvestris*)	222.98	0.32	223.34	0.32
Aardvark (*Orycteropus afer*)	-	-	123.11	0.48
African elephant (*Loxodonta africana*)	254.86	0.1	-	-
Common eland (*Tragelaphus oryx*)	318.26	**<0.01**	126.11	0.51
Common warthog (*Phacochoerus africanus*)	162.83	0.97	165	1
Gemsbok (*Oryx gazella*)	268.9	0.05	265.44	0.06
Giraffe (*Giraffa camelopardalis*)	287.61	**0.01**	234.61	0.22
Greater kudu (*Tragelaphus strepsiceros*)	289.27	**0.01**	156.72	0.89
Grey duiker (*Sylvicapra grimmia*)	254.24	0.11	194.75	0.62
Hartebeest (*Alcelaphus buselaphus*)	-	-	203.89	0.51
Kirk's dik-dik (*Madoqua kirkii*)	176.44	0.85	-	-
Klipspringer (*Oreotragus oreotragus*)	242.78	0.17	-	-
Mountain zebra (*Equus zebra*)	282.8	**0.02**	151.82	0.83
Springbok (*Antidorcas marsupialis*)	242.78	0.17	195.33	0.61
Steenbok (*Raphicerus campestris*)	170.8	0.92	139.54	0.67
Wildlife total	319.36	**<0.01**	222.22	0.33

Figure 23: Examples of waterholes at two different farming systems south of Etosha National Park; waterhole on a game farm (left) and cattle post on a mixed livestock/wildlife farm (right)

In Serengeti Region, the most often recorded wildlife species, the side-striped jackal, shows a significantly lower level of RCF during livestock presence compared to times of livestock absence (Table 11). Since wildlife was exclusively recorded during night-hours, there is a significant higher level of RCF associated with wildlife (total) during night time, when livestock was absent compared to daytime (RCF of livestock: 192.5 events in 100 trap days). The recorded human activity (RCF) is highly significant reduced during night-hours (W=289; p<0.01) compared to daytime (livestock present).

Table 11: Capture frequencies per 100 trap days for recorded wildlife, livestock and humans on pasture with and without livestock presence (276 trap days) in Serengeti Region (table from Rottstock et al. 2020)

SERENGETI REGION	**Median** (IQR) n=17			
Recorded wildlife species	**Night** Livestock absent	**Day** Livestock present	**W-value**	**p-value**
African civet (*Civettictis civetta*)	**0.0** (0.0)	**0.0** (0.0)	127.5	0.16
Black-backed jackal (*Canis mesomelas*)	**0.0** (3.6)	**0.0** (0.0)	119	0.08
Caracal (*Felis caracal*)	**0.0** (0.0)	**0.0** (0.0)	136	0.35
Side-striped jackal (*Canis adustus*)	**0.0** (4.9)	**0.0** (0.0)	110.5	**0.04**
Spotted hyena (*Crocuta crocuta*)	**0.0** (3.6)	**0.0** (0.0)	119	0.08
Striped hyena (*Hyaena hyaena*)	**0.0** (0.0)	**0.0** (0.0)	136	0.35
Wild cat (*Felis silvestris*)	**0.0** (0.0)	**0.0** (0.0)	136	0.35
Bush pig (*Potamochoerus larvatus*)	**0.0** (0.0)	**0.0** (0.0)	136	0.35
Impala (*Aepyceros melampus*)	**0.0** (0.0)	**0.0** (0.0)	136	0.35
Wildlife total	**5.0** (14.8)	**0.0** (0.0)	85	**<0.01**
Cattle (*Bos primigenius* f. taurus/indicus)	-	**135.0** (29.5)	-	-
Goat (*Capra aegarus* f. hircus)	-	**36.6** (16.3)	-	-
Sheep (*Ovis orientalis* f. aries)	-	**25.0** (20.0)	-	-
Livestock total	-	**192.5** (22.5)	-	-
Human (*Homo sapiens*)	**0.0** (3.6)	**55.0** (22.5)	289	**<0.01**

3.1.4 Impact of livestock farming on temporal daily activity patterns of wildlife

When looking at the species-specific ratio of diurnal and nocturnal activity (Table 12), only the roe deer and partially (LOV) the red fox show a notable proportion of activity during daytime in the study areas associated with Germany. Here, all other recorded wildlife species were almost (wild boar) or entirely nocturnal, regardless of livestock presence or absence. Contrary, in Etosha Region more than 70% of the recorded wildlife species revealed considerable amounts of activity during daytime. Regardless of livestock presence or absence, the warthog was predominantly recorded during daylight. Here the black-backed jackal, as only carnivore species that was frequently recorded on both farmins, reveals a higher proportion of activity during daytime on the mixed farm, when compared to the game farm. In contrast, a higher relative activity during night-hours of mainly large ungulate species (giraffe, common eland, greater kudu, mountain zebra and gemsbok) can be observed on the mixed farm compared to the game farm.

Table 12: Ratio of daily activity of wildlife species on pasture with and without livestock presence (table from Rottstock et al. 2020)

Wildlife	Livestock absent		Livestock present	
	Events	% day / night	Events	% day / night
LOWER ODER VALLEY				
Roe deer (*Capreolus capreolus*)	301	17.9 / 82.1	54	37 / 63
Wild boar (*Sus scrofa*)	20	0 / 100	14	0 / 100
European badger (*Meles meles*)	32	0 / 100	11	0 / 100
Raccoon (*Procyon lotor*)	8	0 / 100	1	0 / 100
Raccoon dog (*Nyctereutes procyonoides*)	13	0 / 100	1	0 / 100
Red fox (*Vulpes vulpes*)	92	4.4 / 95.7	28	21.4 / 78.6
HAVELLAND				
Red deer (*Cervus elaphus*)	33	0 / 100	0	0 / 100
Roe deer (*Capreolus capreolus*)	436	45.6 / 54.4	42	23.8 / 76.2
Wild boar (*Sus scrofa*)	37	2.7 / 97.3	0	-
European badger (*Meles meles*)	8	0 / 100	19	0 / 100
Raccoon (*Procyon lotor*)	1	0 / 100	0	0 / 100
Red fox (*Vulpes vulpes*)	90	3.3 / 96.7	110	0 / 100
ETOSHA REGION				
Aardvark (*Orycteropus afer*)	0	-	13	0 / 100
African elephant (*Loxodonta africana*)	5	0 / 100	0	-
Common eland (*Tragelaphus oryx*)	134	23.9 / 76.1	2	0 / 100
Common warthog (*Phacochoerus africanus*)	11	72.7 / 27.3	8	75 / 25
Gemsbok (*Oryx gazella*)	334	49.4 / 50.6	155	25.8 / 74.2
Giraffe (*Giraffa camelopardalis*)	66	72.7 / 27.3	7	14.3 / 85.7
Greater kudu (*Tragelaphus strepsiceros*)	250	58 / 42	27	40.7 / 59.3
Grey duiker (*Sylvicapra grimmia*)	11	45.5 / 54.6	17	5.9 / 94.1
Hartebeest (*Alcelaphus buselaphus*)	0	-	1	0 / 100
Kirk's dik-dik (*Madoqua kirkii*)	6	66.7 / 33.3	0	-
Klipspringer (*Oreotragus oreotragus*)	16	100 / 0	0	-
Mountain zebra (*Equus zebra*)	518	55.4 / 44.6	66	24.2 / 75.8
Springbok (*Antidorcas marsupialis*)	1	100 / 0	49	36.7 / 63.3
Steenbok (*Raphicerus campestris*)	7	57.1 / 42.9	6	100 / 0
Aardwolf (*Proteles cristata*)	12	8.3 / 91.7	6	0 / 100
Black-backed jackal (*Canis mesomelas*)	50	10 / 90	44	27.3 / 72.7
Cape fox (*Vulpes chama*)	0	-	3	0 / 100
Caracal (*Felis caracal*)	4	25 / 75	1	0 / 100
Honey badger (*Mellivora capensis*)	1	0 / 100	1	0 / 100
Leopard (*Panthera pardus*)	1	100 / 0	0	-
Spotted hyaena (*Crocuta crocuta*)	32	15.6 / 84.4	0	-
Wild cat (*Felis silvestris*)	5	0 / 100	2	0 / 100

In all four study areas, the two most often recorded wildlife species show bimodal daily activity patterns (Figure 24). In addition, there is a common tendency to activity peaks related to dusk. In three out of four study areas, wildlife activity is lower during daytime when/where livestock is present on the pasture compared to when/where livestock is absent. The shift of daily activity towards night of the two most frequently recorded wildlife species varies among the study areas (Figure 24). While in Havelland, the wildlife species roe deer (*Capreolus capreolus*) and red fox (*Vulpes vulpes*) reveal a shift of their daily activity patterns towards night in association with presence, the opposite response can be observed in Lower Oder Valley. The two most frequently observed wildlife species in Etosha Region, gemsbok (*Oryx gazella*) and mountain zebra (*Equus zebra*) show a more balanced distribution of their daily activity when compared to the two most often recorded wildlife species from the other study areas. However, in Etosha Region cattle presence is associated with higher activity during night-hours. This difference in the daily activity patterns is more pronounced in mountain zebra compared to gemsbok (Figure 24). In Serengeti Region, wildlife was exclusively recorded during night-hours. Thus, the results are not suitable to compare species-specific response in daily activity. The two most often recorded wildlife species, side-striped jackal (*Canis adustus*) and black-backed jackal (*Canis mesomelas*) show pronounced activity peaks directly before daylight and after dusk (Figure 24). Unlike in wildlife activity patterns, there is a region specific difference in the activity patterns of livestock between the study areas in Germany and sub-Saharan Africa. In contrast to the German study areas, where livestock was recorded all over the day, livestock was almost exclusively recorded during daylight in sub-Saharan Africa (Figure 24).

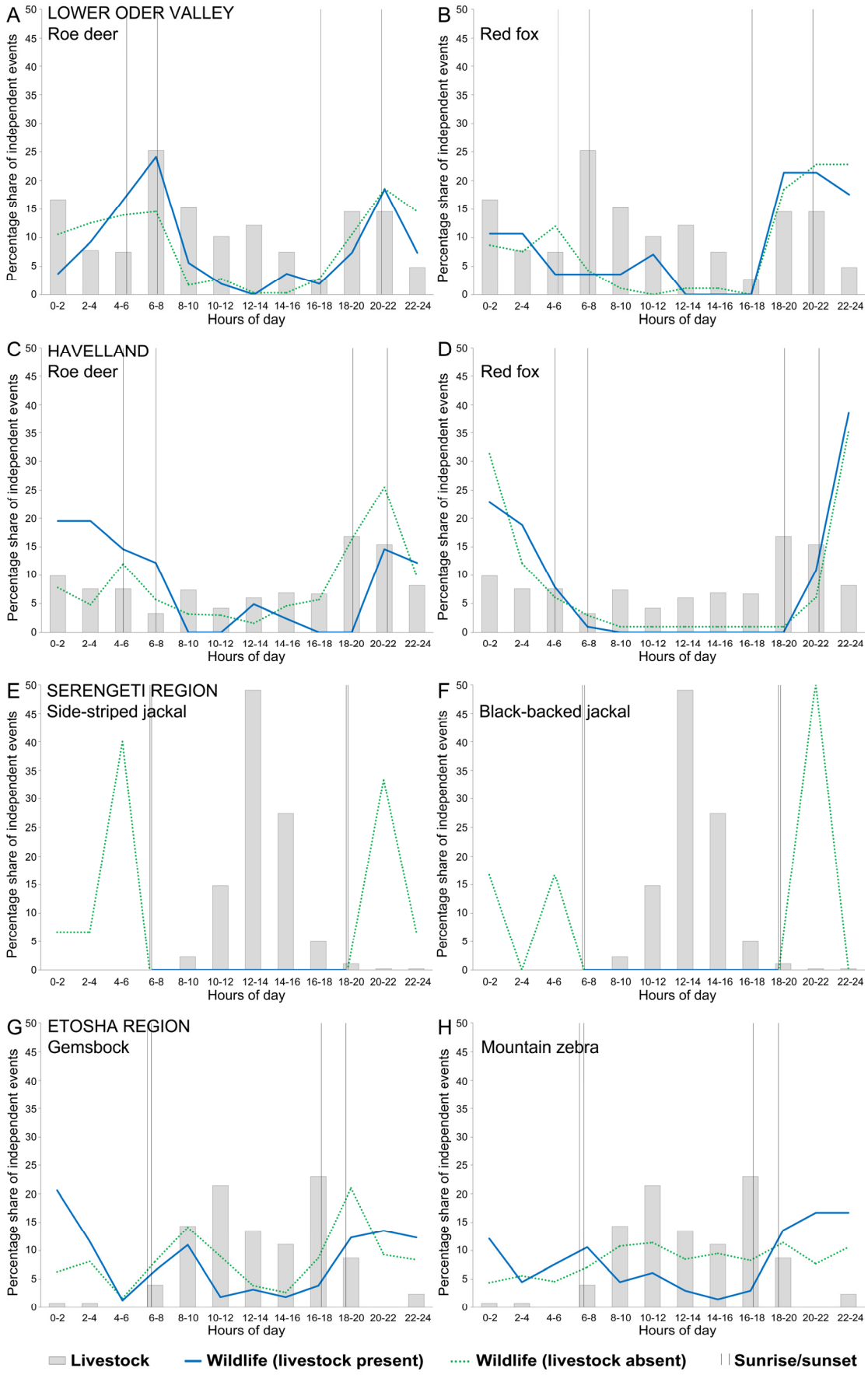

Figure 24: Daily activity patterns the two most often recorded wildlife species per study area on pasture with and without livestock (figure from Rottstock et al. 2020)

3.1.5 Summary of the results from the comparative camera trap surveys

Table 13: Key results of the camera trap surveys (table from Rottstock et al. 2020)

Region	**Central Europe**		**Sub-Saharan Africa**	
Study area	**Havelland**	**Lower Oder Valley**	**Etosha Region**	**Serengeti Region**
Farming system	Rotational grazing	"Naturalistic grazing"	Rotational grazing	Agro-pastoralism
Farming intensity	More intense	Less intense	Less intense	More intense
Fence / Herder	Electrified fence	Electrified fence	Fence without electricity	Herder
Observation effort in trap days	1,291 (n=20)	1,340 (n=20)	1,431 (n=20)	276 (n=17)
Species accumulation curves	Plateau	Plateau	Plateau	No plateau
Potential SR Recorded SR	13 6 (46%)	13 6 (46%)	31 9 (61%)	41 19 (22%)
Change of SR associated with livestock farming	Decrease	Constant	Decrease	Decrease
Potential ungulate-carnivore ratio (SR) in %	46 / 54	46 / 54	61 /39	63 / 37
Recorded ungulate-carnivore ratio (SR) in % Livestock absent Livestock present	 50 - 50 33 - 66	 33 - 66 33 - 66	 63 - 37 65 - 35	 22 - 78 0 - 0
Dominant group of carnivores	Medium sized canids	Medium sized canids	Medium sized canids	Medium sized canids
Changes in ungulate-carnivore ratio (events) associated with livestock farming	Decrease in proportion of ungulates	Decrease in proportion of ungulates	Decrease in proportion of ungulates	-
RCF (IQR) of wildlife Livestock absent Livestock present	 55.1 (49.5) 27.9 (25.7)	 63.4 (68.0) 17.2 (17.2)	 154.61 (120.07) 51.39 (38.89)	 5.0 (14.8) 0.0 (0.0)
RCF (IQR) of humans Livestock absent Livestock present	 4.0 (7.9) 45.5 (175.4)	 0.7 (3.0) 0.0 (0.0)	 0.0 (7.0) 0.0 (1.4)	 0.0 (3.6) 55.0 (22.5)
RCF (IQR) of livestock	513.7 (379.0)	60.4 (28.4)	8.33 (10.4)	192.5 (22.5)
Changes in total wildlife RCF linked with livestock farming	Significant reduction	Highly significant reduction	Significant reduction	Highly significant reduction
Daily activity patterns of livestock	Cathemeral	Cathemeral	Diurnal	Diurnal

3.2 Problem-centred interviews

The results from the social science approach are based on 43 interviews, conducted within the four different study areas (Appendix 7.2.3; Table 14).

Table 14: Period and scope of the interview surveys

Study area	Beginning of survey	End of survey	Interviewees		
			total	farmers	others
Havelland	17.07.2017	05.02. 2017	10	5	5
Lower Oder Valley	27.03.2017	24.04.2017	9	4	5
Etosha Region	01.04.2019	23.05.2019	14	10	4
Serengeti Region	31.10.2017	19.12.2017	10	5	5

3.2.1 Havelland

3.2.1.1 Major human-wildlife conflict associated with cattle farming

Predation of cattle by large carnivores

In the cultural landscape of Havelland, the recolonisation of the wolf (*Canis lupus*) was identified as major HWC associated with livestock grazing (Figure 25). An increasing wolf population and associated conflicts are of concern by 90% of the interviewees and was even mentioned to be a reason to quit cattle farming. 50% of the interviewees desire lethal control of the strictly protected wolves. Farmers, which already had incidents with cattle predation, said that compensation was not paid or was paid after lots of effort. Farmers and hunters mentioned mistrust towards conservationists. Statements include:

- *"the wolves do not fear humans and come close to houses; they recognize easily when they are not hunted"*①
- *"the wolf needs a large habitat but the population is increasing uncontrollably and Germany is too densely populated by humans"*①
- *"wolves should be shot so that they do not spread out further and threaten humans and livestock"*②
- *"we are concerned that the wolf could predate our cattle"*⑤
- *"a calf of mine was killed last year although the cattle was relatively close to the stable"*⑦
- *"I have had more issues with predation of calves but I have not informed the wolf manager, since he did not keep promises"*⑨
- *"some farmers already gave up cattle farming because of the wolves"*⑨
- *"some livestock farmers which neither apply herd protection, nor ask for compensation, since they do not want to be involved in wolf management"*⑩
- *"we should protect the wolf, as we require that countries in Africa protect their dangerous large wildlife, which frequently cause mortality in humans"*⑩

Damage by naturally occurring ungulates

According to 90% of the interviewees, there is a problem with damage of pastures and fields by wild boar (*Sus scrofa*). Although stated as often as cattle predation, conflict through crop damage by wildlife appears less serious. Regarding crop damage, farmers cooperate with hunters, which mitigate this HWC. Hunters are responsible for compensation and consequently try to keep damage low. Statements include:

- *"hunting and damage prevention become increasingly difficult, as the wolf causes disturbance; wildlife becomes more secretly and accumulates in larger groups to reduce predation risk"*②
- *"we support the hunters but expect that they keep crop damages as low as possible"*③
- *"wild boar cause damage on our pasture and crops"*⑤
- *"we manage the wild boar population so that damages on farmland are not serious"*⑥
- *"we have significantly increasing damages on the grassland in particular in protected areas"*⑧

Restrictions of cattle farming through conservation

In Westhavelland Nature Park, restrictions of cattle farming through conservationists are limited to certain areas with high conservation status. 20% of the interviewees mentioned associated conflict between farmers and conservationists. One farmer was complaining that conservationists have mainly economical interests, while ignoring concerns of farmers. Statements include:

- *"most of these organizations are only interested in making money"*⑦
- *"conservationists are only interested in realizing their ideas and do not care about others"*⑦
- *"we are helpless and have to follow their restrictions to not lose the pastures"*⑦
- *"the category nature park is associated with very little restrictions for farmers"*⑧
- *"farmers have to manage the land in nature conservation areas (IUCN Category 4) under strict restrictions, which causes conflict"*⑧
- *"the implementation of nature conservation areas is based on long discussion for compromise finding, which was not always a good solution for both sites; conservationists pushed through their requirements"*⑧

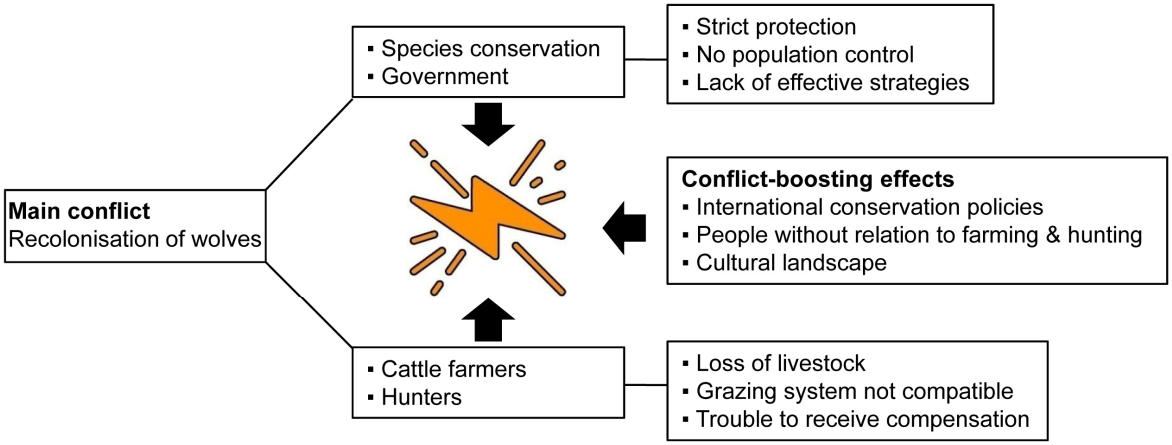

Figure 25: Flowchart - recolonisation of the wolf (*Canis lupus*) as major HWC associated with cattle farming in Westhavelland Nature Park, causes and involved groups of interest

3.2.1.2 Practices to mitigate predation of cattle by large carnivores

None of the interviewed farmers in Havelland mentioned to have an effective strategy to mitigate predation of cattle by wolves (*Canis lupus*). As the species is strictly protected, wolf management focuses on herd protection and awareness creation. Lethal control is only allowed for conflicting wolves, but was mentioned not to be practiced consequently. Interviewees said, that conservationists propose comprehensive electric fencing of pastures to reduce the risk of livestock predation by wolves, although this strategy is not practicable for farmers (Figure 26). Further mentioned strategies, which are supposed to reduce predation of cattle by wolves are: more defensive cattle with horns, cattle close to the house during winter, particularly protected pastures for calving and cows with young calves, regular monitoring, radio on the pasture, seasonal calving, use of drones and dogs. Statements include:

- *"a wolf was in town near the kinder garden but they did not shoot it because officials needed long time to agree"*①
- *"from the office where no grasses are growing they decide that we need a comprehensive electric fence; this is not practicable, it's a lot of effort to hold back the fast growing grasses"*⑦
- *"during winter cattle are close to the house and during summer I have them on a pasture with longer vegetation for calving, so that the calves can hide"*⑨
- *"horns would be good against wolves but also make handling of cattle more risky for farmers"*⑩
- *"a wolf can only be caught or killed for a few serious reasons, as strictly protected species"*⑩
- *"in areas where predation is common, we recommend fences for cattle, which are 90 cm high, are electrified and consist of 4 wires (20 cm, 40 cm, 60 cm and 90 cm)"*⑩
- *"dogs might also be used for the protection of cattle"*⑩
- *"a well fenced pasture for calving and young calves could probably avoid most of cattle predation, as most incidents happen during the first 2 weeks"*⑩
- *"there are ideas to observe pastures automatically with drones"*⑩
- *"herd protection should be as less work intensive as possible"*⑩
- *"we advise the cattle farmers to synchronize the calving"*⑩

Figure 26: Mowing of fences (left); grey wolf /*Canis lupus* (right; photo by Dr. Thomas Göttert)

3.2.1.3 Practices to assure ecological sustainability of cattle farming

All farmers interviewed in Havelland apply rotational grazing of cattle. Since farmers receive subsidies for sustainable livestock farming, stocking densities are adapted according to the available grazing land. Restricted livestock grazing is an important tool in nature conservation. After grazing, pastures are maintained via machinery (harrowed, mulched or mowed) to suppress wooden vegetation (Figure 27). Rotational grazing is limited to the vegetation period, which allows pastures to recover during winter months. All interviewed farmers harvest forage to support cattle during times of shortage and to offer additional fodder on the pasture during grazing (Figure 27). The offspring is usually sold at the end of the vegetation period. Statements include:

- *"the pasture is given time to recover during winter months"*③
- *"I can only keep as many cattle as I can sustain on my land"*③
- *"we receive money for sustainable grassland management from the government"*③
- *"without subsidies cattle farming would not be economical"*③
- *"usually we start grazing cattle in May and bring them back to the stable at the end of October, when the pasture is finished and the offspring is large enough to be sold"*③
- *"we limit the cattle density on the pasture; we keep 0.6 livestock units per ha"*③
- *"during winter our cattle is fed inside the stable (gas-silage, hey and also maize from the fields)"*③
- *"we apply rotational grazing of cattle and start in April; pasture is changed every 2 to 3 days"*⑤
- *"after grazing, pastures are mulched or mowed, so unwanted vegetation cannot grow"*⑦
- *"the cattle can always come to the stable where they get additional forage"*⑦
- *"farmers also mow the grassland to produce fodder"*⑧
- *"grazing of livestock is required and an important management tool in conservation"*⑧
- *"grazing of livestock is suppressed by industrial farming, where livestock is only kept in stables"*⑨

Figure 27: Offer of additional forage on pasture (left); maintenance of pasture by mowing (right)

3.2.1.4 Impact of livestock farming on wildlife presence and activity

All interviewed cattle farmers use one or two mobile electric wires for the rotational grazing of cattle (Figure 28). Although an impact of the electric fences on wildlife was recognised, 60% of the interviewees said that these fences do not necessarily hinder wildlife movement. However, it was mentioned that there is less impact on wildlife when only a single electric wire is used; wildlife learns how to deal with the fences. According to 70% of the interviewees, cattle presence is associated with reduced wildlife presence. Thus, wildlife prefers to stay on rotation pastures when the cattle is not present. 30% of the interviewees mentioned that the roe deer (*Capreolus capreolus*) responds particularly sensitive to the grazing of cattle. There is no common opinion among respondents about competition between cattle and wildlife. Statements include:

- *"the farmers use mainly electrified fences, which they remove after grazing"*②
- *"wildlife moves to neighbouring pastures when cattle is grazing"*②
- *"as the electric wires for cattle farming are relatively high, wildlife can pass without disturbance"*②
- *"wildlife gets used to the cattle; there is no competition with cattle"*③
- *"particularly the roe deer does not like cattle presence, and thus keeps distance to cattle"*⑥
- *"I think a single electric fence is the best option for the wildlife because they can easily pass"*⑥
- *"we use 2 electrified wires for fencing, which have obvious impact on wildlife"*⑨
- *"when the electric power is of and the cattle is not present, wildlife is immediately on the pasture"*⑨
- *"electric fences have a learning effect on the wildlife"*⑨

Figure 28: Two and three electric wires (left) versus single electric wire for fencing of cattle (right)

3.2.2 Lower Oder Valley

3.2.2.1 Major human-wildlife conflict associated with cattle farming

Restrictions of cattle farming through conservation

The major HWC associated with cattle farming in Lower Oder Valley is about competition for land between farmers and conservationists (Figure 30). All interviewees mentioned obvious dispute between farmers and the Lower Oder Valley National Park. The protected area has been implemented in a pronounced cultural landscape without considering local people's interests. Private conservationists keep livestock and continuously purchase farmland in order to generate income, while traditional farmers complain about land grabbing. Despite the small dimension of the Lower Oder Valley National Park, a comprehensive network of institutions, with distinct objectives is involved in the field of conservation (Figure 29). The national park is commonly owned by the government and private conservationists, while different philosophies regarding the development of the protected area are causing conflict. Since core areas do not allow for livestock farming and related incomes, private conservationists hinder the implementation of the national park. Statements include:

- *"it is mainly a legal conflict over land between conventional agriculture and conservation"*④
- *"conservationists force farmers to sign a cooperation contract in which they agree that the rented grassland can be flooded"*⑥
- *"conservationists are only interested in making money to buy more land"*⑥⑨
- *"conservationists take land from farmers which do not follow their rules... so they wanted to destroy my farming business"*⑥
- *"the NP was implemented in a cultural landscape without consideration of peoples interests"*⑦⑨
- *"it exists a land conflict between privately organized conservation and governmental conservation due to competition for land and the ownership of the core area"*⑦
- *"private conservationists want to graze their livestock even in core areas of the national park to generate income from EU subsidies and marketing of cattle products, while the government is against livestock farming in core areas"*⑧
- *"a privately organized conservation founded an agricultural company to purchase land"*⑧
- *"primarily we have conflicts with the privately organized conservation; they buy continuously farm land and spread like cancer"*⑨
- *"a serious conflict between national park administration and private conservationists exists"*⑨

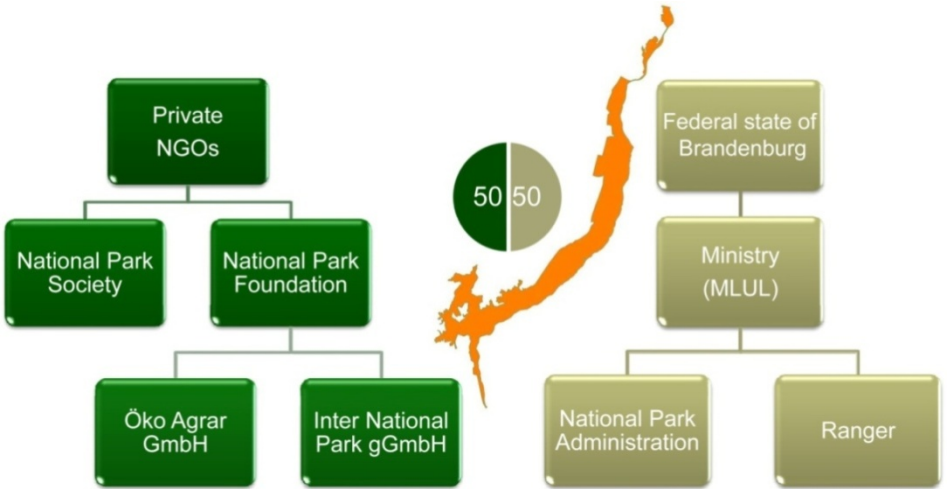

Figure 29: Organisation of conservation institutions in Lower Oder Valley National Park; privately organised conservation (left) and governmental institutions (right)

Damage by naturally occurring ungulates

Conflict through damage (crops, pasture, trees and dams) by wild ungulates was mentioned by nearly 90% of respondents in Lower Oder Valley. However, this was rather described as an issue, which people are used to and know how to deal with. Hunting of ungulates (also in the national park) is the main strategy to mitigate the conflict. Most reported issues were associated with wild boars (*Sus scrofa*). Losses through crop damage by wildlife are compensated by hunters. Statements include:

- *"reduced HWC due to transformation of arable land into grassland and intensive boar hunting"*①
- *"the hunting quantities are planned by estimating wildlife populations"*①⑦
- *"we decide on hunting quantities on the basis of crop damage"*⑤
- *"I have extremely high damages through crop raiding wildlife"*⑥
- *"hunters compensate partly for crop damage but I am not satisfied with that"*⑥
- *"here, hunting is common in all national parks including core areas, as wildlife causes damages in forests and on adjacent farmland"*⑧
- *"the wild boars cause serious damages on our grassland; this problem is increasing"*⑨

Predation of cattle by large carnivores

Although, farmers do not have any experience with predation of livestock by larger carnivores so far, one farmer is very concerned about the recolonisation of wolves. Predation of livestock by wolves is likely to become an issue in the area. Statements include:

- *"wolf presence is reported from time to time but we have not had any issues so far"*②
- *"wolves are sporadically present in the area but we have no experience with predation so far"*④
- *"I got serious heart issues when I heard that wolves were spotted in the region... we have not had predation by wolves so far but it is only a matter of time"*⑥
- *"no problems with livestock predation through wolves so far but the situation is likely to change"*⑦

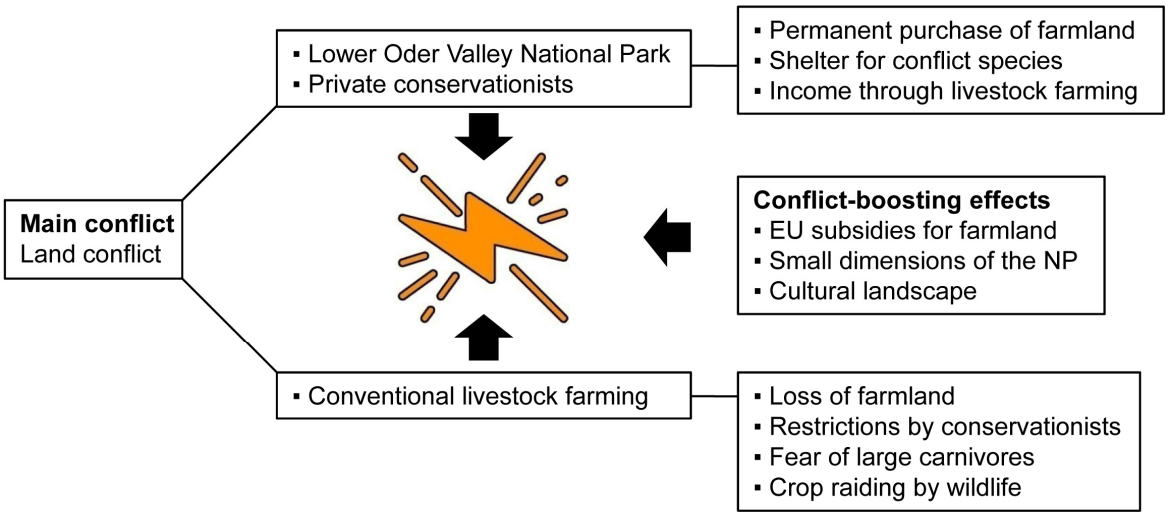

Figure 30: Flowchart - competition for land as major HWC associated with cattle farming in Lower Oder Valley, causes and involved groups of interest

3.2.2.2 Practices to mitigate predation of cattle by large carnivores

Given the increasing threat of cattle by the recolonisation of wolves (*Canis lupus*), farmers are insecure about effective management practices to mitigate predation. However, five out of nine interviewees mentioned ideas, how to deal with the issue: defensive cattle with horns (Figure 31), focus on the protection of calves (grazing close to settlement), more intensive electric fencing and additional fluttery. It was also mentioned that strategies proposed by conservationists are neither effective nor practicable. Statements include:

- *"Heck cattle behave shy and more aggressive compared to other cattle"*②
- *"our calves graze close to the farm"*③
- *"conservationists are not honest; electric fences will not hinder wolves from predating livestock"*⑥
- *"we fence the pastures for calves with electric net-fences to protect them from wolves"*⑥
- *"farmers would need more dense electrified fences and additional fluttery"*⑦

Figure 31: Additional fodder for cattle on pasture (left); long horned Heck Cattle (right)

3.2.2.3 Practices to assure ecological sustainability of cattle farming

All interviewed farmers said that they limit the grazing pressure through adapted stocking rates. Next to the traditional rotational grazing, which is applied by 75% of these farmers, there is also "naturalistic grazing" in Lower Oder Valley. This grazing system was introduced by conservationists and is characterised by year-round grazing of livestock (permanent pastures), low stocking density and minimal management effort. Financial subsidies for sustainable farming are given by the agricultural policy of the EU. Restricted grazing of cattle is an important management tool in certain zones of the national park. All interviewed farmers produce fodder to support the cattle during winter months (Figure 31). The mowing of grassland suppresses wooden vegetation. Statements include:

- *"as the livestock density is too high for the grassland we feed hey during winter"*②
- *"the mowing of grassland to produce hey suppresses woody vegetation"*②
- *"more cattle on the pasture during the vegetation period and only a few during winter months"*③
- *"intensive grazing and mowing of grassland is desired by the national park during certain times"*③
- *"rotational grazing allows the grassland to recover and prevents damages of the grassland"*⑤
- *"farmers receive money for sustainable grazing of livestock"*⑦⑨
- *"due to restrictions by conservationists we cannot manage the grassland intensively"*⑨

3.2.2.4 Impact of livestock farming on wildlife presence and activity

All interviewed farmers use electrified wires to fence cattle pastures (Figure 32). Although none of the interviewees said that these fences have significant impact on wildlife, one third of them mentioned that the disturbance of wildlife increases with the quantity of electrified wires. More electrified wires are used for the present fencing in "naturalistic grazing" compared to rotational grazing, where fences are only seasonally present. Consequently, two out of nine interviewees mentioned less wildlife disturbance through rotational grazing compared to "naturalistic grazing". The general opinion is that wildlife habitually get used to the grazing of cattle and associated fences. However, one third of the interviewees mentioned that the roe deer (*Capreolus capreolus*) responds more sensitive to cattle farming compared to the wild boar (*Sus scrofa*). According to five out of nine interviewees, human presence is associated with wildlife disturbance. None of the interviewees mentioned direct competition between livestock and wildlife. Statements include:

- *"the rotational grazing system comprises only a single electrified wire, while three electrified wires cause reduced wildlife quantity in permanent pastures"*①
- *"in rotational grazing, wildlife disturbance is limited to summer months"*①
- *"human presence acts as stressor for wildlife"*①
- *"we mainly use one, sometimes two electrified wires and after the vegetation period fences are removed from the grassland"*③
- *"I have observed, that wildlife is able to handle the fences for cattle farming well"*⑥
- *"the roe deer does not necessarily enter the fenced pasture they wait until the fences have been removed; the wild boar is not so much disturbed by the fences and cattle"*⑦
- *"where shepherds are with the livestock all day, even the wild boar is careful"*⑧
- *"I think that the permanent fencing with electric wires has a negative impact on wildlife"*⑨

Figure 32: "Naturalistic grazing" of cattle with electrified fences in Lower Oder Valley National Park

3.2.3 Etosha Region

3.2.3.1 Major human-wildlife conflict associated with cattle farming

The two identified major HWC associated with cattle farming are about economic losses of farmers through predation of cattle by carnivores and infrastructure damage by elephants (Figure 35).

- *"the major regional conflicts between wildlife and farming are hyenas and elephants"*⑥
- *"predators and elephants are our biggest problems"*⑦
- *"maybe they are extinct in the world but in Namibia there are far too many elephants and cheetahs"*⑧

Predation of cattle by large carnivores

All interviewees in the Etosha Region mentioned problems with predation of cattle by larger carnivores (Figure 33). According to 50% of them, numbers of large carnivores are too high and/or livestock predation is increasing. Interviewees reported predation of cattle by spotted hyenas (*Crocuta crocuta*), lions (*Panthera leo*), cheetahs (*Acinonyx jubatus*), leopards (*Panthera pardus*) and black-backed jackals (*Canis mesomelas*), while the caracal (*Felis caracal*) was only an issue for small stock. 11 out of 14 respondents said that the spotted hyena is the most problematic species when it comes to cattle predation. Statements include:

- *"populations of large carnivores have increased a lot during the last years"*①
- *"mostly there are conflicts between cattle farmers and wildlife farmers when the wildlife farmers do not care about the predators"*②
- *"predation makes farming difficult; our biggest problem are the hyenas, originating from Etosha"*⑥
- *"there were less predators in former times; the spotted hyena has increased as well as lions"*⑨
- *"my biggest problem with predators is the spotted hyena and then leopards and cheetahs"*⑬
- *"there are many problems with predators, not only next to national parks but increasing all over Namibia with enormous impact on the country's economy"*⑬
- *"predation has increased a lot because there are so many government owned farms now where there is no control; and lodges, who want the predators for the tourists"*⑭

Figure 33: Predation of cattle mostly by spotted hyena (*Crocuta crocuta*)

Damage by naturally occurring ungulates

All interviewees mentioned conflicts between commercial farmers and strictly protected elephants (*Loxodonta africana*), damaging essential infrastructure (e.g. fences, windmills, water ponds) (Figure 34). Elephants used to be commonly managed in conservancies on commercial land. However, these conservancies are not recognised by the government anymore. Consequently, increasing numbers of elephants are moving to commercial livestock farms. 50% of the interviewees reported to have serious issues with elephants and said that elephant populations should be controlled through hunting to reduce the conflict. Some farmers are so desperate that they illegally shoot the strictly protected elephants. Statements include:

- *"the elephants cause serious financial damage; they eat everything and damage our fences and windmills; they need to be shot as elephants and farmers cannot coexist"*①
- *"in former times the elephants were controlled through hunting but now their numbers have increased; they became just too many and need to be controlled"*①
- *"former conservancies on commercial land, which are abolished by the government should remain to manage the elephants commonly by farmers and compensate economic losses"*③
- *"if we see them we shoot them to get them out of the properties; especially when you are a cattle farmer you cannot arrange with elephants, there is no way"*⑤
- *"farmers in the south and east of Kamanjab have a lot of problems with elephants, which originate from Etosha and make farming more difficult and unsustainable"*⑥
- *"if they shoot one elephant the whole world will complain; they have a management plan but they do not kill them because they are scared"*⑧
- *"I got permission from the government to shoot two elephants last year but under the conditions they require it is impossible; the elephants come only for one hour; in this time you must bring together a trophy hunter and a ranger and a PH for big 5, we tried this for 6 months"*⑧
- *"I shot many elephants illegally because it is the only solution I have, I just shoot them in the stomach that they go and die in the park"*⑧
- *"we had problems with elephants, you cannot imagine the devastation; so there is conflict with the neighbouring wildlife farms"*⑩

Figure 34: Elephant (*Loxodonta africana*) cause conflict through infrastructure damage

Restrictions of cattle farming through conservation

12 out of 14 interviewees are complaining about conflicting wildlife species entering commercial livestock farms. These wildlife species are reported to come from Etosha National Park, lodges with eco-tourism or government resettlement farms. Mentioned reasons are insufficient control of wildlife populations and maintenance of fences. Due to land use change these areas are increasing to the expense of neighbouring livestock farms. The fence along the southern boundary of Etosha National Park functions as veterinary cordon fence, crucial for commercial livestock farming, as required for meat export to the EU. However, the findings also show that a harmonious relationship between neighbouring livestock and wildlife farmers is possible when the populations of conflicting wildlife species are controlled. Statements include:

- *"the biggest problem is that the wildlife numbers in Etosha are becoming too high and they come out"*⑥
- *"we need the national park but the problem with farmers next to the national park is that when the fences are not in good condition, they get problems with the wildlife"*⑥
- *"the southern border of the national park is a veterinary cordon fence; our beef export to Europe depends on that fence"*⑧
- *"predators come from all over, as lots of farms are only wildlife farms now, they breed there"*⑧
- *"there is no hunting inside Etosha National Park"*⑧⑨
- *"wildlife farmers tolerate the predators more than we do and then we have conflicts with them"*⑨
- *"we must protect ourselves from land use change on our costs and we do not have any benefit of that at all only losses"*⑬
- *"wildlife cannot just accumulate in numbers to the expense of the neighbouring areas, it must be managed as well"*⑬
- *"we farmers do not really work together with conservationists because there are so many laws and regulations in place from the government side"*⑭

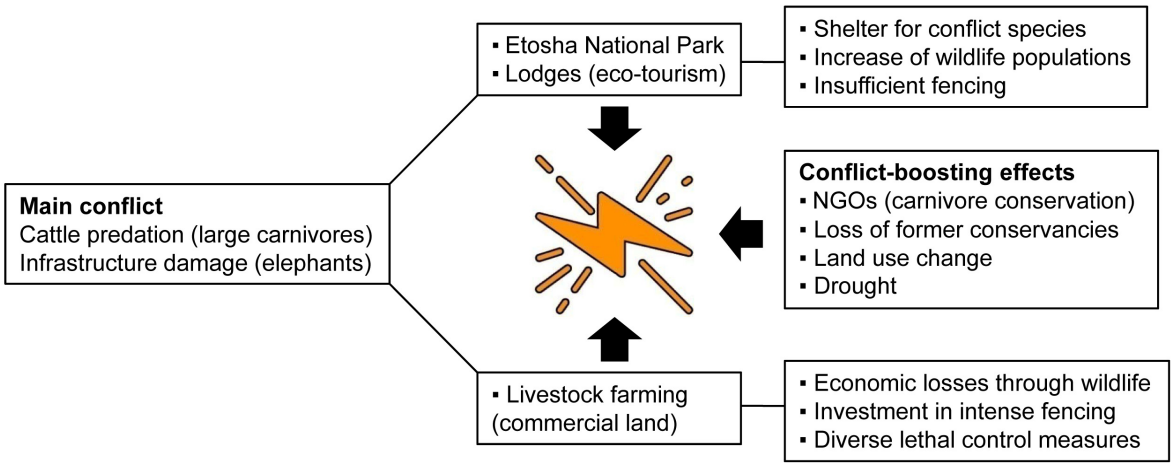

Figure 35: Flowchart - cattle predation and infrastructure damage as major HWCs associated with cattle farming in Etosha Region, causes and involved groups of interest

3.2.3.2 Practices to mitigate predation of cattle by large carnivores

Farmers have several practices to deal with predation of livestock through larger carnivores (Figure 36). The basic strategy is lethal control of conflicting carnivores. Thus, all interviewees practice hunting. Farmers are allowed to kill carnivores when they predate livestock. Other mentioned methods are cage and leg traps, poison as well as overrunning them by car. Due to the use of cage traps, lives of carnivores can be saved. Farmers have the opportunity to give caught carnivores to wildlife foundations. However, 50% of the interviewees mentioned mistrust towards these organisations. Some of the interviewees said that only after I turned off the voice recorder. Preventive measures are only applied by 8 out of 14 interviewees and were mostly described as not functioning, as not practicable or as not cost effective (e.g. use of fire, human presence, donkeys, cattle with horns, electrified fences, seasonal calving and kraal). However, focussing on the protection of calves was mentioned to be an effective strategy by five farmers. Thus, small fenced areas for calving and young calves are established close to settlements. According to four cattle farmers, there is no difference in predation risk of cattle with and without horns. Farmers even give up livestock keeping because of predation or invest a lot into game prove fences to keep out carnivores. There is nothing like compensation for losses through wildlife or benefit sharing from conservation. Statements include:

- *"we farmers have to protect ourselves, so we try to shoot them, but they are smart, so we use traps and poison them"*①
- *"electric fences are not the thing to do, as carnivores can learn to cross them"*②
- *"it is legal for farmers to kill carnivores when they predate livestock, it has to be reported within 24 hours; when there are too many lions, permits for trophy hunting are sold"*③
- *"we are not supported by the government at all, there is no compensation, nothing"*⑤
- *"I did seasonal calving but when pregnant cows are chased by predators they get abortions, so you can not apply the unnatural seasonal calving because you would have less cows calving"*⑧
- *"when we catch a cheetah and we do not want to kill it we call the Cheetah Foundation but our experience is they will come back; if they tell you they resettle cheetahs successfully don't believe them that's bullshit, they just release them somewhere else"*⑨
- *"we shoot them first and then report it, there is no time to report first when we run into them; we need no evidence because we are fulltime farmers, they take your word"*⑩
- *"you can put a cage or get a hunter from aboard that helps to recover some of the money which you have lost; you can also put out bait"*⑩
- *"I have a few cows with horns; it was an experiment but it didn't work, the hyena eats them with horns or without horns"*⑪
- *"it is impossible to protect the cattle because they are in the field, I have many cattle and it is not possible to bring all of them to the house"*⑫
- *"the ideal way would be to bring highly pregnant cows to the house in a small camp where you can watch them but the facilities are not always there and you would have to monitor all the cattle every day, so it is better for me to do electrical fencing and keep the predators out but the first option is to get rid of them"*⑫

• *"the NGOs are begging for money all over the world and they do it emotional; they say they are protecting the cheetahs but they use all the donor money for their luxurious lifestyle (buy vast areas of farmland, drive luxurious vehicles); not a single cent goes to the people who carry the losses"*⑬
• *"sometimes we must sleep outside in the field, which is time consuming and harsh for the whole family"*⑬
• *"I will upgraded and electrify my fences soon, but I am not convinced that it will be that effective; it is to labor intensive because every day you need to maintain the fences"*⑬
• *"the NGOs do not tell the truth; it is not good to blame all the farmers like that, but so they make money"*⑭
• *"farmers don't want to give cheetahs to NGO_a[2] anymore; they do not want to give them to NGO_b[2], NGO_c[2] or NGO_d[2] because they don't trust these people and rather shoot the predators"*⑭
• *"predators first stopped me from livestock farming and then they stopped me from trophy hunting; they forced me to go into tourism business"*⑭

Figure 36: Selected practices to mitigate predation of cattle by larger carnivores; use of traps (left) and use of a kraal for protection of cattle during night (right)

[2] The names of the organizations (NGOs) mentioned have been anonymized

3.2.3.3 Practices to assure ecological sustainability of cattle farming

12 out of 14 interviewees apply measures to counter bush encroachment on their pastures. The most often mentioned method was the harvest of young bushes for the production of so-called bush feed. Thus, some farmers even see the bushes as an asset during drought. Further mentioned measures are chemical herbicides, mechanical destruction, charcoal burning and goat farming (Figure 37). Although none of the interviewees use fire as management tool, 11 out of 14 think it could have potential to control bushes. Effective fires can only build up when there are enough grasses present. But grasses are rare during drought and are valuable forage for livestock. Furthermore, fire is difficult to control. All interviewed cattle farmers applied rotational grazing and adapt the stocking rate to the available pasture. However, during drought, rotational grazing is not feasible and farmers are forced to reduce the number of animals. All interviewees offer additional fodder during drought. They mainly buy it, although some farmers produce in limited scale. Statements include:

- *"we do not burn the pastures; the bushes are good; they offer also pasture for cattle; during drought it is the only available pasture and rescues the cattle"*①
- *"we mow grass to produce hey, but this is only possible in years with good rain"*①
- *"a loader with a big iron roller is used to flatten the bush, which dies afterwards"*③
- *"we produce charcoal to reduce bush encroachment; we do not make too much money out of the charcoal but it covers the costs"*⑤
- *"during drought grazing management changes, I reduce the amount and mainly keep cows"*⑥
- *"we produce Lucerne ourselves, but only on a small-scale, as water is limited "*⑦
- *"we do not put fires on the farm to control bushes because we need the grass for the livestock"*⑧
- *"I make so called bush feed, but you cannot feed all the cattle with bush feed. it is impossible; I only feed 20 cattle at the time until they are fat and then I sell them"*⑧
- *"we do rotational grazing; the rotation depends on the availability of grass"*⑩
- *"we are very scared of fire because it is hard to control; you are in trouble when your neighbors farm starts to burn"*⑩
- *"we applied chemicals from an airplane, it will kill everything (not selective) but if the season is long enough the grass will grow again"*⑩
- *"goats are very good in utilizing the bush but unfortunately there is no market for goats"*⑬

Figure 37: Selected practices for the control of woody vegetation, charcoal burning (left) and production of livestock fodder (right)

3.2.3.4 Impact of livestock farming on wildlife presence and activity

10 out of 14 interviewees mentioned competition over pasture between cattle and naturally occurring grazers (mainly gemsbok and mountain zebra), particularly pronounced during drought. All cattle farmers use low fences without electricity to enclose pastures for cattle grazing. None of them said that these fences would hinder wildlife. In contrast, 9 out of 14 interviewees mentioned that high game fences hinder wildlife movement and causes starvation of wildlife during drought. However, 30% of the interviewed cattle farmers decided to enclose their farms with a high game fence as response to increasing livestock predation by carnivores (Figure 38). Statements include:

• "we do not have a game fence so wildlife can migrate, hunting farms usually have a dense fence which is a big problem for wildlife during droughts"①
• "wildlife is avoiding cattle, as there is competition for forage"③
• "cattle does not disturb wildlife necessarily, they can sometimes be found together at a waterhole"④
• "it's an open system with the neighbours, we rely on each other to do it in a sustainable way"⑥
• "single farms are too small for effective wildlife management"⑨
• "cattle has no real impact on the wildlife but the other way around; when there are too many oryx and zebras they are competing with the cattle because they are all grazers"⑨
• "the wildlife is not scared away by the livestock but they usually do not come the same time as the cows because the cows you find during the hottest time of the day at the water hole; the game comes earlier or later on but it is not a rare thing to see oryx together with cows"⑩
• "wildlife is better adapted to drought compared to cattle, but on a fenced farm during drought wildlife is more difficult to manage compared to cattle because cattle I can be fed in a kraal"⑫
• "I use normal cattle fences 5-7 wires, they have no impact on game movement"⑬
• "oryx tend to move out when the cattle is in the camp, they move to the camps where there are no cattle and they utilize the grazing"⑬
• "I have put a game fence (2.4 m), an electric fence inside and outside (1.7 m) and now want to also put jackals prove fence (1 m) around the farm; this will stop predators to 95%"⑭

Figure 38: Cattle fence (left) versus game fence (right)

3.2.4 Serengeti Region

The people in this study area belong to diverse ethnic groups (e.g. Ikoma, Kuria, Maasai, Nata, Sukuma) and are mainly subsistence farmers (agro-pastoralists).

3.2.4.1 Major human-wildlife conflict associated with cattle farming

Restrictions of cattle farming through conservation

The main HWC identified in the Serengeti Region is competition for land between livestock farmers and conservationists (Figure 40). All interviewees mentioned conflict due to illegal grazing of cattle in Serengeti National Park. There is serious shortage of resources and associated competition between livestock farmers (agro-pastoralists) and areas set aside for conservation of wildlife (Figure 39). Despite the effort to involve communities into conservation, 70% of the interviewees mentioned that there is a lack of benefit sharing and/or cooperation between farmers and conservationists. An investor is paying for all hunting licences, while conducting eco-tourism only. Consequently, wildlife numbers and associated HWC are increasing. Although illegal, 90% of the interviewees mentioned that poaching is common. Statements include:

- *"there is not enough grass and the grazing area is decreasing"*①
- *"the major conflict here is that we graze the cattle illegally inside the national park"*①②
- *"all wildlife is protected by rangers and we are not allowed to hunt"*②
- *"there is a buffer zone by law, which is not implemented; you can even find settlement"*⑤
- *"poaching is very common in the region; traditional values are attached to these activities"*⑤
- *"the area became very friendly for wildlife; so the animals come very close to the villages, which increases interaction and causes much conflict*⑤
- *"the government plan is to extend the Serengeti up to the Lake Victoria and wants to shift the people, living between Lake and national park to other areas"*⑥
- *"government is only interested in money and not in wildlife; there is a need for benefit sharing"*⑨
- *"there is no partnership between livestock farmers and the government (protected areas)"*⑨
- *"the government is increasing buffer zones and other protected areas including WMAs where access to grazing land becomes increasingly difficult; that is where the conflict comes from"*⑨
- *"the solution would be participatory land use planning that involves us pastoralists"*⑨
- *"an investor pays all hunting fees but uses wildlife for eco-tourism only"*⑩
- *"the government wants to vacate all people from the area and get all revenues from tourism"*⑩
- *"some villages would like to deregister from WMAs because they get not enough benefits"*⑩

Figure 39: Intense livestock farming on communal land adjacent to Serengeti National Park (left) and grazing wildebeest in Serengeti National Park (right)

Predation of cattle by larger carnivores

All interviewees mentioned that there is human-wildlife conflict through predation of cattle by large carnivores, most frequently (70%) with the spotted hyena (*Crocuta crocuta*). Other carnivores are lions (*Panthera leo*) and leopard (*Panthera pardus*), which come from the national park to communal land mainly during night. Statements include:

- *"the hyenas come from the national park to the village land and kill our livestock"*②③
- *"lions, hyenas and leopards can cause predation of livestock, but this is not a big issue"*⑥
- *"there is livestock predation in particular by hyenas it is a big problem"*⑦
- *"conflicts with lions have increased"*⑧

Damage by naturally occurring ungulates

70% of the interviewees mentioned HWC with elephants. The elephants come from the national park to village land and destroy infrastructure and crops of agro-pastoralists. These incidents are increasing, while there is no sufficient reimbursement. One farmer said that the acceptance of wildlife is higher in livestock compared to crop farming. Statements include:

- *"when animals like the elephant come to graze on our crops they are not paying us, but when our animals go to the park for grazing then we have to pay fines"*②
- *"elephants come from the national park during harvest season and destroy our crops"*③
- *"we have a serious problem with the elephants, which destroy our crops and break trees"*④
- *"we don't have a strategy against elephants because this is a new situation for us"*④
- *"problems with elephants have increased in the region"*⑦⑧
- *"farmers can apply for consolation (not compensation); the amount paid is not sufficient and does not come on time"*⑦

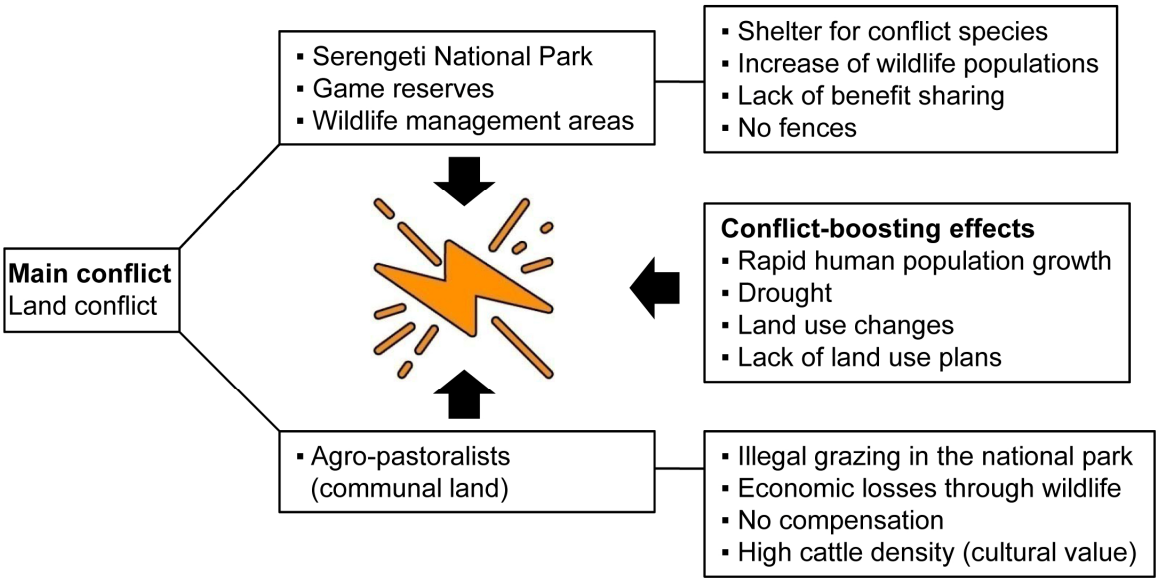

Figure 40: Flowchart - competition for land as major HWCs associated with cattle farming in Serengeti Region, causes and involved groups of interest

3.2.4.2 Practices to mitigate predation of cattle by large carnivores

All interviewees mentioned that livestock enclosures (bomas) are used to mitigate predation of cattle by carnivores during night (Figure 41). Farmers apply a combination of methods to chase away large carnivores during the night (e.g. use of dogs, human presence, light and noise). Occasionally, security lights in the bomas and electric fences are used. Calves are particularly protected; they stay in a stable during the night and graze close to the settlement during the day. Pastures are not fenced, but cattle is guided by human herders and dogs during the day. There are different opinions among the respondents regarding the value of horns for the defence of cattle against carnivores. Since illegal, lethal control measures were not mentioned by farmers. However, conservationists said that farmers also kill large carnivores. There is no compensation for livestock losses through carnivores but farmers can apply for small consolation, which is difficult to obtain. Statements include:

- *"goat sheep and calves are inside a stable to protect them from hyenas during the night"*①
- *"we use many dogs, which act as guards during the night"*②
- *"we go out with the torch and chase the hyena away by using the light"*③
- *"long horns can help the cattle to defend their calves against predators like hyenas"*③
- *"horns are only decoration; they do not help cattle to defend themselves from predators"*④
- *"we use strong bomas during the night and herders look after the livestock during the day"*⑤
- *"a piece of land close to the settlement for weak and small cattle; only strong cattle moves far"*⑤
- *"sometimes people poison and lay snares, but the farmers would not tell you"*⑥
- *"farmers do not receive compensation, only consolation"*⑧
- *"we rather believe in preventive measures to change attitudes instead of compensation"*⑩

Figure 41: Selected practices to mitigate predation of cattle by larger carnivores; boma and stable (left), cattle with long horns and human herder (right)

3.2.4.3 Practices to assure ecological sustainability of cattle farming

All interviewees mentioned unsustainable grazing of cattle in the Serengeti Region. According to 70% of them, there is a lack of land use planning. 60% of the interviewees mentioned issues with bush encroachment and/or soil erosion resulting from intensive livestock farming (Figure 42). However, farmers have no common strategy for pasture maintenance. Mentioned practices, which are conducted on a small scale only, are manual removal of woody vegetation as well as production of charcoal and firewood as a source of income. 80% of the interviewees mentioned recent land use change; former pastoralists live in permanent houses nowadays. Despite the lack of pasture on communal land, 40% of the respondents said that fire is commonly used as management tool within adjacent protected areas. Although traditionally used for pasture management, farmers are not allowed to burn rangeland. It was also mentioned that elephants can suppress bushes. Statements include:

- *"we make charcoal and firewood to gain income, necessary to buy food for our survival"*①
- *"when the pasture is finished and the animals start to suffer and even die, cattle can cause erosion but we have to continue grazing"*①
- *"the cattle quantity is connected with prestige"*①
- *"we like to invest in cattle because it acts like a bank account"*②
- *"in the past we could move freely, but now due to increasing human population we cannot migrate easily because every piece of land is owned by someone"*③
- *"we livestock keepers are just looking after our cattle; we don't care about the environment"*④
- *"we remove trees and bushes from the rangeland because they germinate themselves and disturb farming; these bushes are a result of livestock keeping"*④
- *"in the Serengeti many elephants always clear the bushes and fall the trees; so regeneration becomes very difficult"*⑤
- *"in former times the population of people was not very high and many regions were not occupied by people; pastoralists were moving according to rain- and dry seasons"*⑤
- *"pastoralists like permanent houses; they started crop farming as an alternative way of life"*⑤
- *"fragmentation of rangelands is a serious issue, as mobility is very crucial for pastoralism"*⑤
- *"pastoralists prefer to have a large number of livestock, particularly cattle to sustain their big families, comprising several wives"*⑤
- *"we don't have facilities to maybe bring hay; for us all these techniques are not suitable, because we do not invest much"*⑤
- *"big challenge for the sustainability of protected areas are cattle and human population growth"*⑤
- *"overgrazing through unsustainable land use is an issue"*⑥
- *"there is a need for management practices which help to build resilience to withstand droughts"*⑥
- *"the major issues is how to manage the little land for all the competing needs that there are"*⑥
- *"we need to introduce land use plans in the villages to support the wildlife"*⑦
- *"fires are frequently used as management tool inside protected areas"*⑦
- *"there is a lot of bush encroachment through grazing of cattle outside the protected areas, which reduces the available grazing land and brings the cattle into the protected areas"*⑧
- *"they need to make sure that they keep livestock numbers according to the amount of land that they have, otherwise the conflict with livestock inside protected areas will increase"*⑧

- *"the main issue is competition for resources"*⑨
- *"pastoralists used to keep as many cattle as they can and are still doing that in some places"*⑨
- *"they think, the higher the number of livestock, the more of them will remain after a drought"*⑨
- *"overgrazing is happening because the pastoralists are forced to stay at one place nowadays"*⑨
- *"farmers used to burn to suppress bush encroachment but it is prohibited now"*⑨
- *"I think soil erosion is a bigger problem than bush encroachment"*⑩

Figure 42: Harvest of firewood (left), land degradation by erosion and bush encroachment (right)

3.2.4.4 Impact of livestock farming on wildlife presence and activity

70% of the interviewees mentioned, that the grazing of cattle negatively affects the presence and behaviour of wildlife. There is no uniform opinion among the interviewees about the disturbance of wildlife through cattle presence. No fences, but human herders, are part of the pastoral grazing system (Figure 43). Despite the absence of fences, there is a sharp boundary between Serengeti National Park and bordering communal land. High human population density, intensive livestock farming (mainly cattle) and further human activities are associated with reduced wildlife presence on communally managed rangelands. 30% of the interviewees said that wildlife is particularly avoiding the communal rangeland during the day. As described in chapter 3.2.4.1, there is pronounced competition for pasture. According to 40% of the interviewees, wildlife species respond differently to grazing of cattle. Statements include:

- *"wildlife stays in the national park because it does not like disturbance through human activities"*①
- *"during the day the wildlife hides somewhere"*①
- *"the disturbance of wildlife through the grazing of cattle is species specific"*①
- *"I or my children herd the cattle during the day; we do not have fences"*③
- *"hyenas come usually only during night, as they fear humans"*④
- *"even the large mammals (e.g. zebra, wildebeest, antelopes and gazelles) used to come here, but since the population of people has increased in the area, they are not coming anymore"*④
- *"the land use outside and inside the WMA is very different, because of highly populated villages with a big number of cattle, highly grazed outside"*⑤
- *"where the cattle is, there is no wildlife, they stay away"*⑦
- *"there are no fences used in the area neither by farmers nor conservationists"*⑦
- *"the disturbance of wildlife through cattle grazing is due to human presence (herders)"*⑧
- *"particular during migration there is competition for resources when wildlife grazes on village land"*⑧
- *"crop farming can affect the movement of wildlife but not livestock grazing"*⑨

Figure 43: Herding of cattle during the day by human presence (left) and dogs (right)

3.2.5 Cross-case comparison

3.2.5.1 Questionaire data

• Motives of farmers for the grazing of cattle

In four out of six observed motives of farmers for grazing of cattle, results from study areas in Germany and Namibia reveal similarities, while the one from Tanzania show a different picture (Figure 45 a,b,c,f). Only the parameter landscaping reveals clear region-specific differences between study areas associated with Germany and sub-Saharan Africa (Figure 45 d). Contrary to most interviewed farmers in Germany, landscaping is not a reason to keep cattle for farmers in the African study areas (Figure 44).

Figure 44: Use of cattle for landscaping in Germany (left) and as labour force in Tanzania (right)

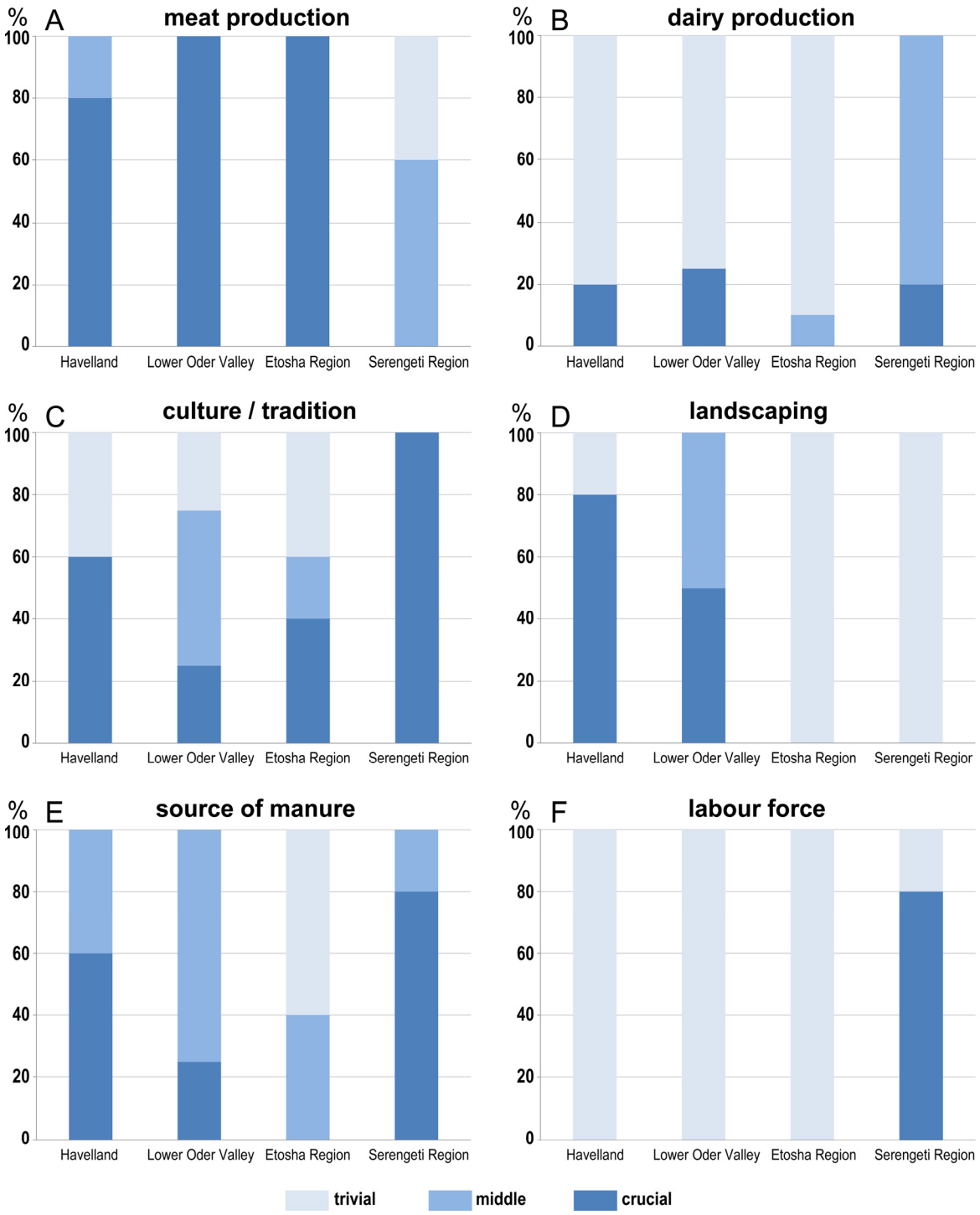

Figure 45: Motives of farmers for the grazing of cattle in Havelland (n=5), Lower Oder Valley (n=4), Etosha Region (n=10) and Serengeti Region (n=5)

• Important characteristics of cattle breeds

When comparing the preferred characteristics of cattle breeds among the four study areas, once more findings from the Serengeti Region reveal a different picture compared to the other study areas. This can be found in three out of four observed parameters (Figure 46 a,c,d). Only robustness of cattle was crucial to a similar level for farmers in all study areas.

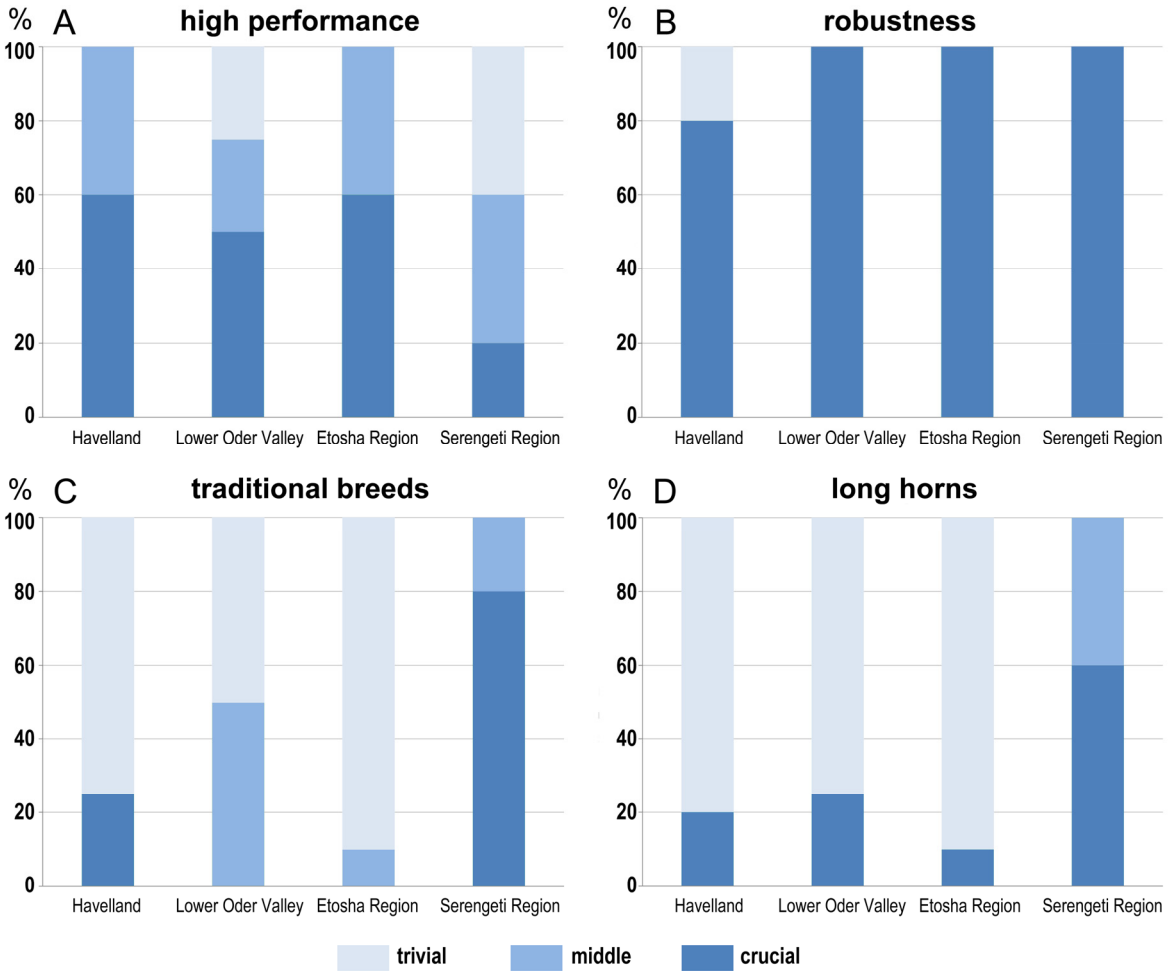

Figure 46: Important characteristics for the choice of cattle breeds by farmers in Havelland (n=5), Lower Oder Valley (n=4), Etosha Region (n=10) and Serengeti Region (n=5)

• Basic parameters of cattle farming

Next to the special role of the Serengeti Region compared to the other study areas, which can also be found in the basic parameters of cattle farming (Figure 47 b,d), there is an extreme difference between the two study areas associated with sub-Saharan Africa (Figure 47 c, d; Figure 48 c).

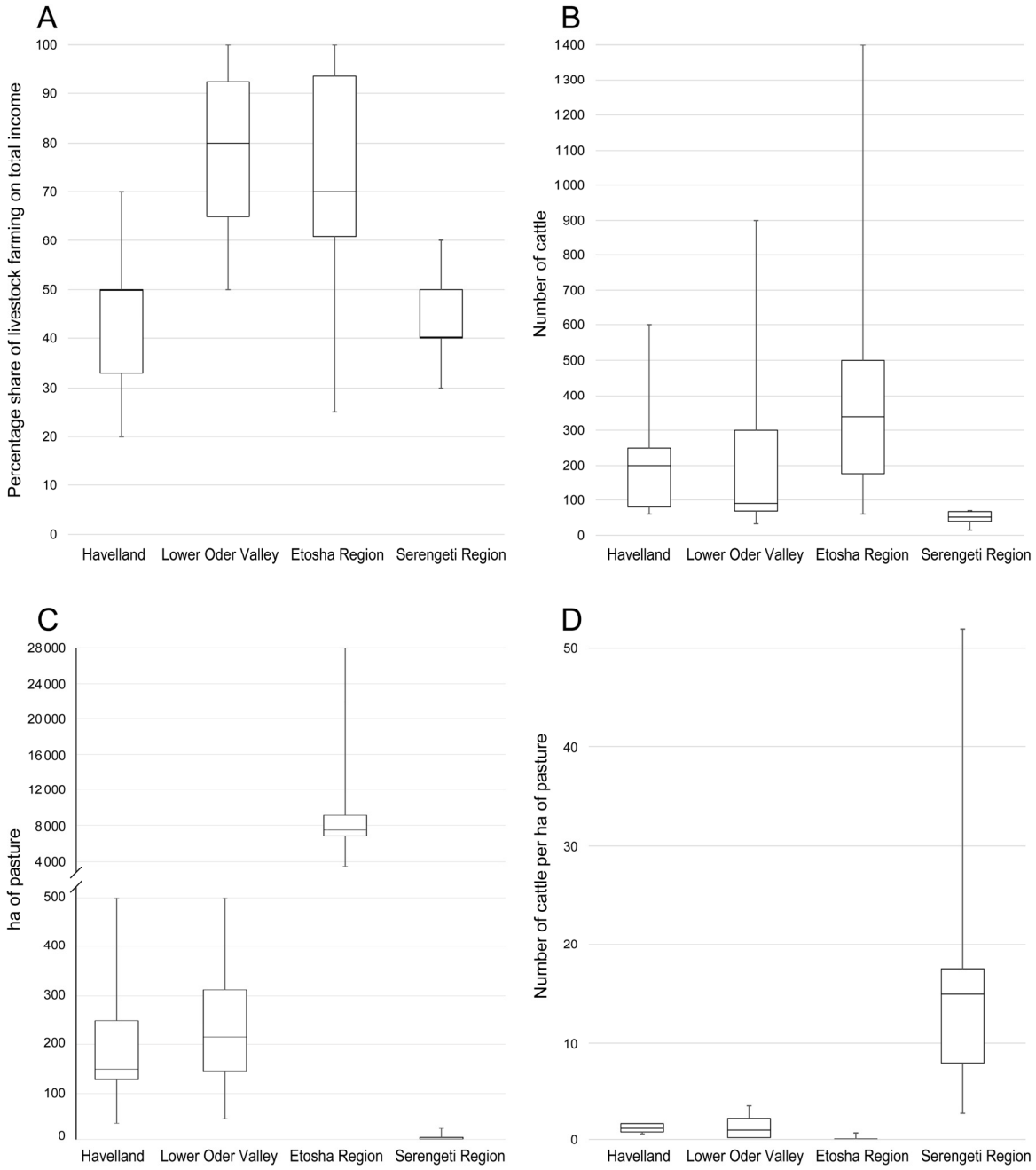

Figure 47: Median and inter quartile range (25-75%) of importance of livestock farming for income (A); no. of cattle kept (B); ha of pasture (C); stocking rate (D) in Havelland (n=5), Lower Oder Valley (n=4), Etosha Region (n=10) and Serengeti Region (n=5)

However, the basic parameters of cattle farming also reveal region specific differences between study areas associated with Germany and sub-Saharan Africa (Figure 48 a,d).

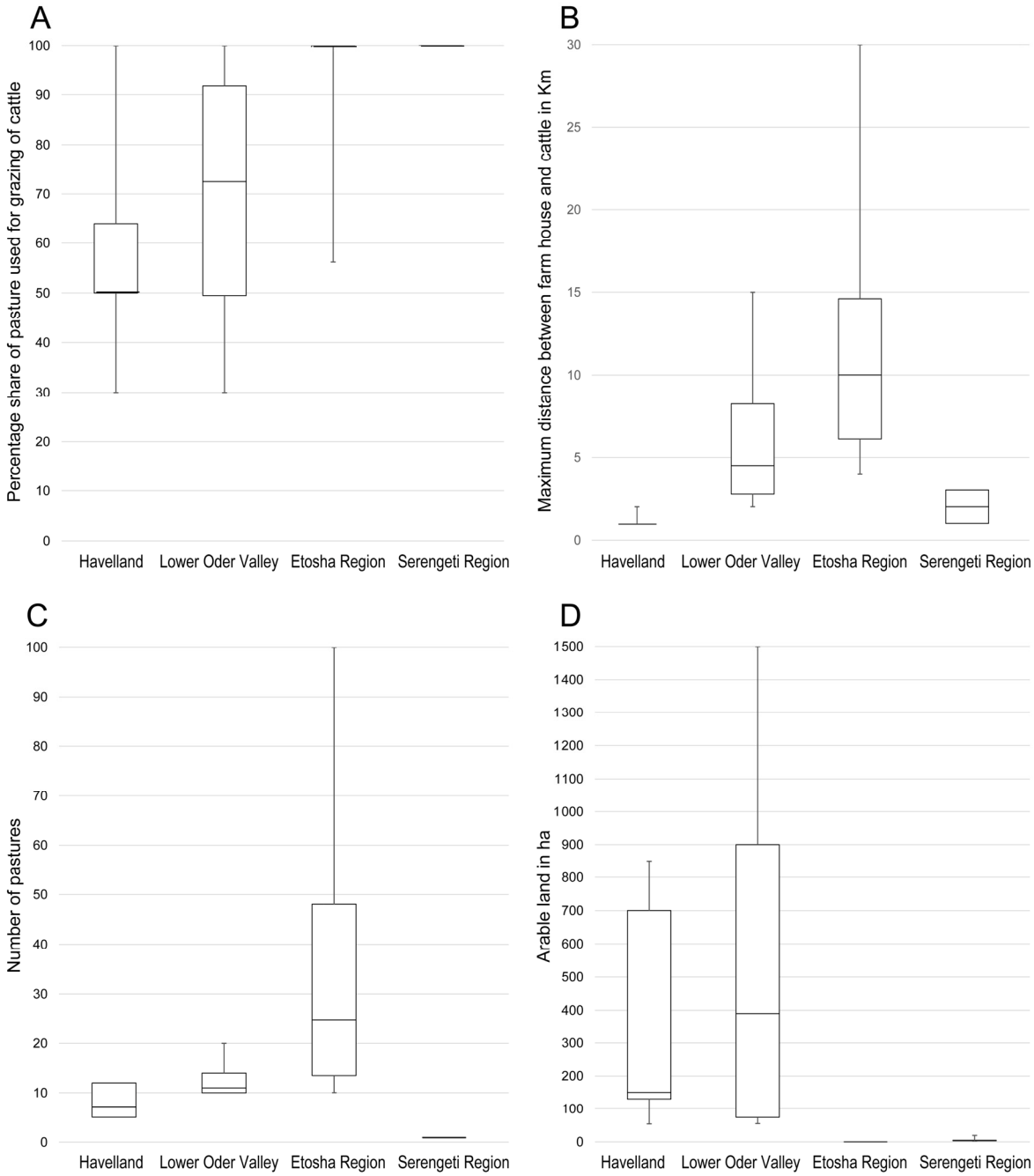

Figure 48: Median and inter quartile range (25-75%) of percentage of pasture used for grazing (A); maximum distance between farm and cattle (B); no. of pastures (C); ha of arable land (D) in Havelland (n=5), Lower Oder Valley (n=4), Etosha Region (n=10) and Serengeti Region (n=5)

• Use of cattle breeds and further livestock for grazing

In contrast to study areas in Africa, a rich variety of cattle breeds (exclusively *Bos primigenius* f. taurus) is kept by interviewees from study areas in Germany (Table 15). 80% of the interviewed livestock farmers in the Etosha Region keep crossbreeds, while the so called Simbra, a combination of Bramahns (*Bos primigenius* f. indicus) and Simmentaler (*Bos primigenius* f. taurus), is dominating. The only cattle kept by interviewees from the Serengeti Region is the Tanzanian Shorthorn Zebu (*Bos primigenius* f. indicus) (Table 15, Figure 49). While the majority of interviewed farmers in African study areas graze additional livestock, this is not the case for farmers interviewed in study areas associated with Germany.

Table 15: Use of cattle breeds and further livestock in the four study areas

Study area	Interviewee	Kept cattle breeds	Other livestock
HVL	3	Charolais, Fleckvieh	None
HVL	4	Holstein-Friesian, Uckermärker	None
HVL	5	Uckermärker, Fleckvieh	Pigs, poultry
HVL	7	German Angus	None
HVL	9	Crossbreeds	None
LOV	2	Heck cattle	Horses
LOV	3	Braunvieh, DSN, Angler Rotvieh, Tiroler Grauvieh	None
LOV	6	Galloway, Angus, Shorthorn, crossbreeds	Sheep
LOV	9	Uckermärker, Simmentaler	None
NAM	1	Simbra	None
NAM	4	Simbra	Sheep
NAM	6	Braunvieh x Bramahns	None
NAM	7	Bonsmara x Tuli x Limousin	Sheep, goat
NAM	8	Africanas x Bramahns	Sheep
NAM	9	Bramahns, Simbra	Sheep
NAM	10	Bramahns, Jersey	Sheep
NAM	11	Bonsmara	None
NAM	12	Simbra	Sheep
NAM	13	Simbra	Sheep
TZ	1	Tanzanian Shorthorn Zebu	Sheep
TZ	2	Tanzanian Shorthorn Zebu	Sheep, goat
TZ	3	Tanzanian Shorthorn Zebu	Sheep, goat
TZ	4	Tanzanian Shorthorn Zebu	Sheep, goat
TZ	9	Tanzanian Shorthorn Zebu	None

Figure 49: Examples of different kept cattle breeds from left to right: Charolais in HVL, Heck cattle in LOV, Simbra in NAM, Tanzania Shorthorn Zebu in TZ

3.2.5.2 Interview data

• Stakeholder functions and relations

The three-factor analysis of stakeholder functions and relations reveals the existence of three focal groups, whereby each focal group consists of stakeholders from different study areas (Figure 50; Appendix 7.2.5). Interestingly, all interviewees from Serengeti Region belong exclusively to focal group A (cattle farming) or B (conservation). Group A and Group B include also interviewees from Etosha Region and Havelland but not from Lower Oder Valley. Except from the Serengeti Region, focal group C (hunting) contains interviewees from all other study areas. Interviewees from Etosha Region and Havelland can be found in either focal group as well as outside of the focal groups. In total, 53% of all interviewees are part of one of these focal groups. The remaining interviewees, which are not part of a focal group, mostly belong to the study areas of Lower Oder Valley and Etosha Region.

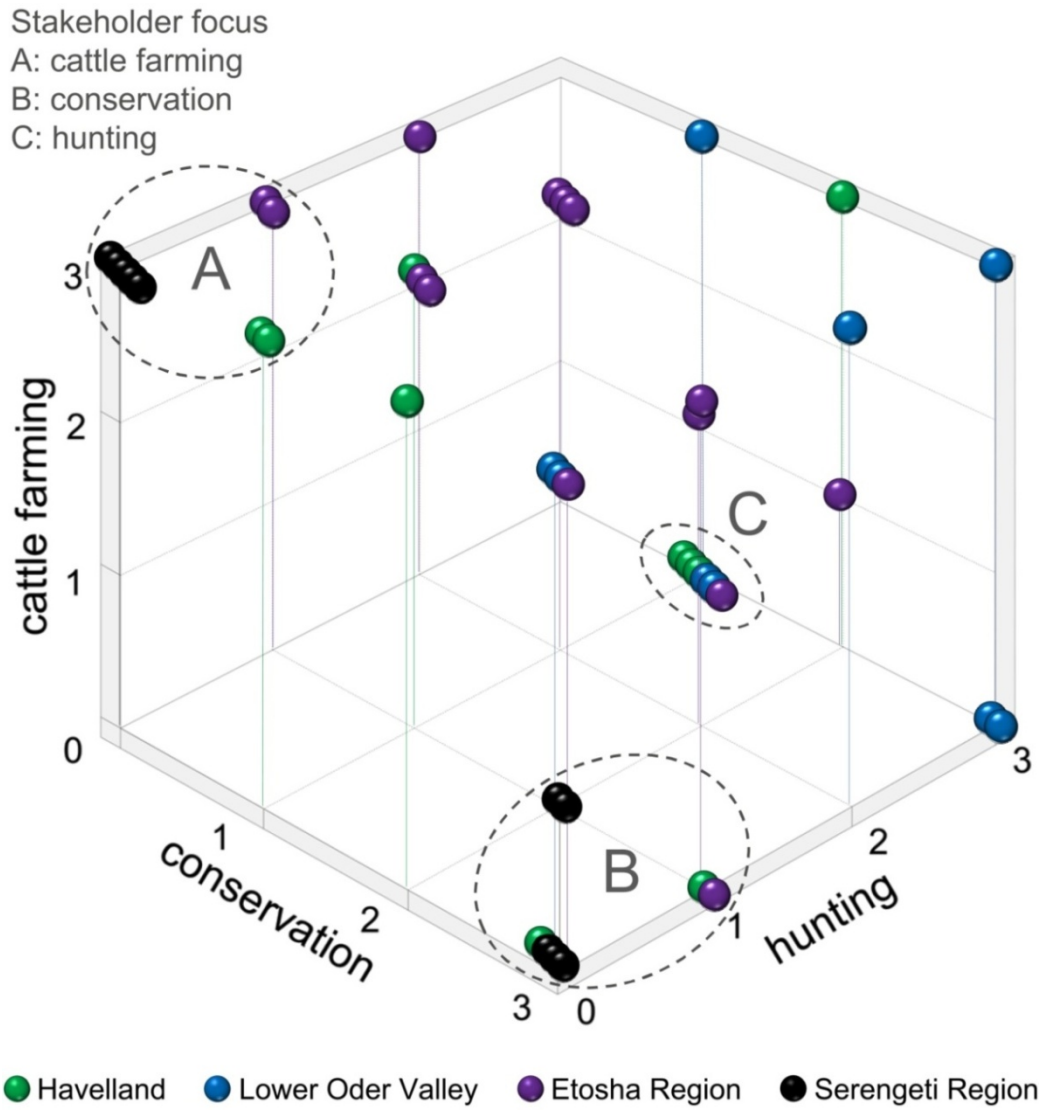

Figure 50: Ranking of the interviewee's engagement in the three land use forms: cattle farming, conservation and hunting (Havelland n=10; Lower Oder Valley n=9; Etosha Region n=14; Serengeti Region n=10)

- Major HWC associated with cattle farming

Table 16: Major regional HWC associated with cattle farming in comparison

Havelland	Lower Oder Valley	Etosha Region	Serengeti Region
• Nature park	• National park	• National park	• National park
Restriction of cattle farming by conservation			
• Governmental conservation only	• Governmental conservation plus privately organized conservation	• Governmental conservation plus privately organized conservation	• Governmental conservation plus privately organized conservation
• 20% mentioned conflict through restrictions of farmers by conservation • Restrictions are on a small scale only	• 100% mentioned dispute between farmers and conservationists • Obvious land conflict • Conflict between governmental and privately organised conservation	• Loss of farmland through protected areas is no issue	• 100% mentioned dispute between farmers and conservationists • Obvious land conflict
• Restricted grazing of cattle is integrated in protected area management		• Cattle farming excluded from national parks	• Illegal grazing of cattle in protected areas
• Hunting is the main strategy to mitigate conflicts with unprotected wildlife species on farmland and in protected areas		• Hunting more intense on farmland compared to protected areas	• No Hunting on farmland and in protected areas
• Interests of farmers are not considered by conservationists • Conservationists pursue economical interests to the expense of farmers		• NGOs make money through large carnivores • No sharing of benefits	• 70% mentioned lack of benefit sharing from conservation
• Obvious lack of cooperation between farmers and conservationists & mistrust towards conservationists			
• Increasing numbers of grey wolf (*Canis lupus*) in cultural landscape, but no effective strategies for mitigation of HWC		• Increasing numbers of elephants (*Loxodonta africana*) are leaving protected areas, but no effective strategies for mitigation of HWC	
Predation of cattle by large carnivores			
• Concern of 90% of the interviewees • Can be reason to quit cattle farming • 50% desire lethal control of wolf population	• Non of the interviewees have had experience • Serious concern of one farmer	• 100% mentioned issues with predation of cattle • 50% mentioned to high numbers of carnivores • Conflict mainly with spotted hyena	• 100% mentioned issues with predation of cattle • Conflict mainly with spotted hyena
Losses through naturally occurring ungulates			
• 90% of the interviewees stated that wild boar (*Sus scrofa*) damage pastures and fields • Farmers are used to the issue and know how to deal with it		• 100% mentioned damage of infrastructure by elephants • 50% have had serious issues and desire lethal population control • Lack of effective strategies	• 70% mentioned damage of crops and infrastructure by elephants • Lack of effective strategies

Most pronounced HWC exist due to restrictions of cattle farming by conservation in Lower Oder Valley and Serengeti Region (Figure 51). Associated conflict was much lower in the other study areas. Although present in all study areas, HWC through wild ungulates is more pronounced in Africa compared to Europe. Except for Lower Oder Valley, conflict through predation of cattle by large carnivores was mentioned by the majority of interviewees. In contrast to Africa, interviewees from German study areas perceived conflict through predation of cattle as more serious compared to damage by wild ungulates. Among all study areas, identified HWC is the lowest in Havelland.

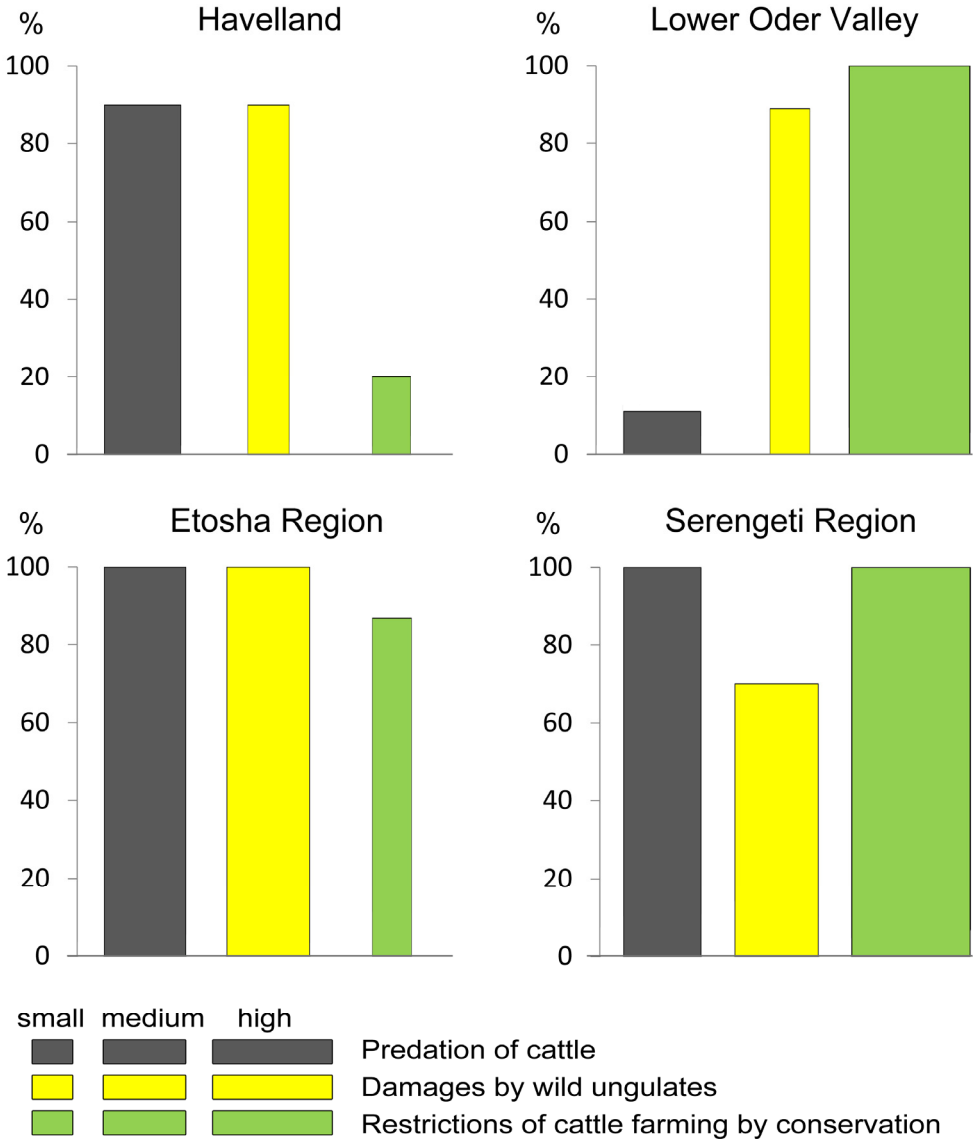

Figure 51: Percentage and significance (width of bars) of the mentioned three major HWC associated with cattle farming in the four study areas (Havelland n=10; Lower Oder Valley n=9; Etosha Region n=14; Serengeti Region n=10).

- Practices with potential to mitigate cattle predation by large carnivores

Table 17: Practices with potential to mitigate cattle predation by large carnivores

Havelland	Lower Oder Valley	Etosha Region	Serengeti Region
• No regular lethal control		• Shooting • Trapping • Poisoning • Overrunning by car	• Illegal lethal control is common (poaching)
• Cattle with horns • Cattle close to the settlement during winter • Pasture for calving and cows with young calves • Regular monitoring • Radio on the pasture • Seasonal calving	• Hope that horned cattle can avoid predation through wolves • Pasture for young calves	• Dense electrified fences • Human presence during night • Defensive cattle breed • Pasture for calving and calves	• Protection of cattle during night (boma, light, dogs, noise) • Particular protection of calves during night • Human presence • Grazing of calves close to settlement
• Conflicts with compensation system for livestock predation (responsibility of state)		• No compensation	• No compensation • Insufficient consolation

- Practices to assure ecological sustainability of cattle farming

Table 18: Ecological sustainability of cattle farming

Havelland	Lower Oder Valley	Etosha Region	Serengeti Region
• No issues through overgrazing		• Bush encroachment	• Bush encroachment • Soil erosion
• Restricted grazing of livestock as tool in nature conservation		• Livestock excluded from Etosha NP	• Livestock excluded from SNP
• Stocking density according to available pasture • Reduction of number of cattle at the end of the growing season		• Try to adapt stocking rate • Reduction of cattle quantity during drought	• Try to keep as many livestock as possible (also during drought)
• Subsidies for sustainable grazing of cattle • Pasture maintenance (mowing, mulching) • Rotational grazing limited to vegetation period • Harvest of forage for times of shortage		• Bush as source of forage • Chemicals to kill bushes • Mechanical removal of bushes • Charcoal production • Fire is not practicable • Goats suppress bushes • Offer additional fodder	• Fire is a tool in protected areas only • Low livestock mobility • Harvest of firewood • Low input subsistence farming

- Impact of livestock farming on wildlife presence and activity

Table 19: Impact of livestock farming on wildlife presence and activity

Havelland	Lower Oder Valley	Etosha Region	Serengeti Region
• Impact of fences increases with the quantity of wires • Wildlife mortality due to electric net-fences • Impact of fences on wildlife is temporally and spatially limited in rotational grazing, compared to "naturalistic grazing" • Wildlife prefers pastures, where cattle is not grazing at the time • Competition between cattle and wildlife is no issue • Larger pastures and less cattle density is better for wildlife • Roe deer responds particularly sensitive to cattle farming • Human presence is associated with wildlife disturbance		• Low fences of cattle farms are better for wildlife movement compared to high game fences • Pronounced competition between cattle and wildlife for pasture • Wildlife response to grazing of cattle is species specific	• Human presence (e.g. herders) cause considerable avoidance of rangelands by wildlife • Interviewees describe a sharp boundary between SNP and adjacent rangelands (despite the absence of fences) • Pronounced competition between cattle and wildlife for pasture • Wildlife response to grazing of cattle is species specific • Wildlife particularly avoids rangeland during the day

4 Discussion

4.1 Camera trap surveys

This comparison of grazing systems for livestock from central Europe and sub-Saharan African is based on the assumption that relatively undisturbed African savannas can function as valuable reference for a more sustainable grazing management in highly transformed European grassland ecosystems (Zeller et al., 2017). Disturbance in this context refers to "*any relatively discrete and sudden event in time that disrupts the structure of ecosystems, communities and populations, changing resources pools, substrate availability, or the physical environment*" (Pickett and White, 1985, p. 7). Due to human activities, the species diversity of the Pleistocene megafauna has been considerably reduced in Europe and all other populated continents except Africa (Bartlett et al., 2016). Thus, when compared to the German study areas the numbers of potential target species are more than two times as high in the African study areas (Table 5). This reflects in the flatter species accumulation curves from Havelland (HVL) and Lower Oder Valley (LOV) compared to the curves from Etosha Region (NAM) and Serengeti Region (TZ). Moreover, unlike in Germany, the potential ungulate-carnivore ratio in the African study areas is biased towards ungulate species (checklists of the protected areas [Appendix 7.1.1]).

4.1.1 Serengeti Region - distinct edge effects despite the absence of fences

High human population density and associated high transformation of rangelands at the western border of Serengeti National Park (SNP) (Arcese et al., 1995) are associated with pronounced edge effects adjacent to the protected area. Given obvious reservations of local people regarding camera traps, the data collection at SNP was stopped after less than two weeks. It is not uncommon that camera trap surveys become subject of vandalism and theft by humans (Meek et al., 2018).

Unlike the species-accumulation curves from the three other study areas the species accumulation curve from the Serengeti Region does not plateau (Figure 19). This indicates that the camera trap effort spent in Serengeti Region was insufficient (Thompson and Withers, 2003). It can be assumed that the recorded number of target species in Serengeti Region would have increased with further observation effort. The information obtained during the parallel conducted interviews proves the presence of several more wildlife species on the observed rangeland next to Serengeti National Park. Serengeti National Park (reference area for TZ) comprises the highest quantity of potential target species (n = 41) among the four study areas. Despite the close proximity of the camera trap survey to SNP (Figure 17), the Serengeti Region is the only study area, where the presence of livestock was associated with no recorded wildlife activity on the observed rangeland. Also during night-hours, when livestock is kept in bomas (small enclosures made of thorny brushwood) and when the human activity (RCF) is low (Table 11), ungulate species (impala [*Aepyceros melampus*] and bush pig [*Potamochoerus larvatus*]) were recorded only sporadically. In contrast to SNP, the observed neighbouring communal rangeland was mostly lacking any grasses during the time of data collection. Thus, it is not surprising that ungulate species have little motivation to come to the overgrazed communal rangeland, even during night-hours when livestock is absent and human activities are low.

In the Serengeti Region, photographic events of wildlife relate almost exclusively to carnivores (Table 11). Here, the most often recorded carnivore species was the side-striped jackal (*Canis adustus*), followed by black-backed jackal (*Canis mesomelas*). Corresponding to the observed RCF of the two jackal species in the Serengeti Region, Loveridge and Macdonald (2003) reported *Canis adustus* preferring close vicinity to human settlements, while *Canis mesomelas* rather favour open rangelands. The third often recorded carnivore species is the spotted hyena (*Crocuta crocuta*). This species is known to be attracted by human settlements (Bohm and Höner, 2015).

However, most wildlife species appear to avoid the communally managed rangeland next to SNP. Several of the wildlife species, which could be observed inside SNP from the location of the camera traps that were positioned close to the national park border, were not recorded via the camera traps on neighbouring communal rangeland. This phenomenon let assume that there is a pronounced land use contrast between SNP and

the observed communal rangeland, which directly borders the protected area. There is no fence or other physical barrier. Unlike in other parts of western Serengeti (Walpole et al., 2004), there is no effective buffer zone to mitigate HWC.

Despite the insufficient observation effort in Serengeti Region, the collected data point to a high degree of human transformation. Compared to the other study areas, human activity (RCF) was the highest in Serengeti Region. Next to the herding of livestock, local people were frequently searching for natural resources (e.g. firewood). It is known that high human population densities are associated with a high level of wildlife disturbance (Mittermeier et al., 2003). Since poaching of wildlife is common at the western border of SNP (e.g. Loibooki et al., 2002; Kaltenborn et al., 2005; Kaswamila, 2007; Olff and Hopcraft, 2008), this can be assumed to have an influence on the wildlife behaviour in this study area. Hunting by humans can cause wildlife responses similar to predation (Schuette et al., 2016). A study from the USA for instance reveals that white-tailed deer (*Odocoileus virginianus*) respond to human hunting with increased nocturnal activity and avoidance of open areas (Klingo et al., 1998).

These results from Serengeti Region (no wildlife activity associated with livestock presence, low observed species richness and unnatural ungulate-carnivore-ratio) are probably not exemplary for the entire study area. However, the findings indicate the extreme transformation of the landscape and the existence of pronounced human-wildlife conflicts in this region (Hampson et al., 2015). The lack of an implemented buffer zone at the studied rangeland probably also contributes to the results in Serengeti Region.

4.1.2 Etosha Region - wildlife response points towards vulnerability of large species

The detection of more than 60% of the potentially occurring wildlife species in Etosha Region (NAM) confirms the importance of privately managed rangeland as wildlife habitat at the southern border of Etosha National Park (Göttert and Zeller, 2008; Mannetti et al., 2017; 2019). Several studies compared different farming systems in Namibia and have shown clear effects of free-range livestock farming on soil, flora and fauna (Zeidler et al., 2002; Hoffmann and Zeller, 2005; Vohland et al., 2005; Muck and Zeller, 2006; Wesuls et al., 2013; Hauptfleisch et al., 2017). Furthermore, studies from the African continent have shown disturbing effects of livestock grazing on large naturally occurring ungulates (e.g. Georgiadis et al., 2007; Bhola et al., 2012; Kimuyu et al., 2017). However, the effect of livestock farming on wildlife appears to be much more moderate in Etosha Region when compared to the results from the Serengeti Region. Compared to the other study areas, the findings from Etosha Region reveal the most natural composition of wildlife communities. Here ungulates clearly dominate over carnivores in species richness and RCF. Additionally, unlike in the other three study areas most wildlife species could be observed during hours of daylight in Etosha Region.

Several ecological parameters were similar at both farms in Etosha Region. The two observed farming systems for instance reveal a comparable richness of target species (game farm: n=19 species, mixed farm: n=17 species). On both farms, the most frequently recorded species were the large grazers mountain zebra and gemsbok. Among wildlife, particularly large ungulate species reveal a clear difference between the two farms in NAM. Although, the observed game farm was not high-fenced and does not pursue economical interest by maintaining high wildlife numbers several large ungulate species (giraffe, common eland, mountain zebra and greater kudu) reveal significantly lower RCFs on rangeland associated with cattle farming compared to the game farm.

Since habitat conditions have impact on the capture probability of wildlife species (Yoccoz et al., 2001; Ancrenaz et al., 2012), the highly significantly lower level of RCF of the mountain zebra on the mixed farm is probably not only a result of cattle grazing, but also different habitat conditions at both observed farms, especially the rocky outcrops on the game farm. The more sandy soils on the mixed farm, compared to the game farm could also explain the exclusive occurrence of Cape fox (*Vulpes chama*) and aardvark (*Orycteropus afer*) on the rangeland associated with cattle grazing. Both wildlife species prefer rather open landscapes and sandy soils (Skinner and Chimimba, 2005).

It has to be considered that not only livestock grazing but also other human activities have impact on wildlife (Schuette et al., 2016). For example hunting activities can affect the presence and activity of wildlife species (Di Bitetti et al., 2008). The exclusive recording of large carnivore species, mainly spotted hyena (*Crocuta crocuta*), on the game farm probably results from higher hunting pressure on the mixed farm. A study from Kenya

shows that spotted hyenas respond to persecution by livestock farmers with increased vigilance on respectively used rangelands (Pangle and Holekamp, 2010).

Regarding the daily activity patterns of wildlife in Etosha Region, predominantly large ungulate species were more nocturnal on the mixed farm when compared to the game farm. This species specific response of wildlife to cattle grazing can be explained with competition over limited resources (Happold, 1995; Voeten and Prins, 1999; Ogutu et al., 2009; Odadi et al., 2011). A further reason for this finding could be increased vigilance and flight behaviour as common response to human activities (Frid and Dill, 2002; Stankowich, 2008).

Additionally larger ungulates (common eland, giraffe, greater kudu and mountain zebra) reveal significant preference of proximity to waterholes (increase of RCF) on the wildlife farm, while this effect was not found on nearby mixed farm. The different temporal use of water points by livestock and wildlife indicates competition. Zvidzai (2012) found pronounced interactions between wild and domestic herbivores during dry season at waterholes on farmland adjacent to Gonarezhou National Park in Mozambique. An attracting effect of water points on wildlife in African protected areas is also described by other authors (Owen-Smith, 1996; Smit et al., 2007; Schwabe et al., 2015), while de Leeuw et al. (2001) found that wildlife avoids vicinity of water points on rangelands with livestock presence in Kenya. On the one hand, wildlife in southern Africa can benefit from manmade waterholes on farmland, particularly during times of drought (Loarie et al., 2009; Zvidzai, 2012), while on the other hand artificial boreholes allow for year-round grazing, which often leads to overgrazing and habitat degradation, with negative impact on humans and wildlife (Thomas et al., 2000; de Leeuw et al., 2001; Sinclair et al., 2008; Loarie et al., 2009).

4.1.3 European grazing systems - how beneficial is “naturalistic grazing” for wildlife?

Two fundamentally different grazing systems were observed in Germany - rotational grazing in Havelland and “naturalistic grazing” in Lower Oder Valley. While the observed pasture in Lower Oder Valley was located directly adjacent to a national park, the studied rotation pasture in Havelland was located in an area with lower protection status (nature park).

Rotational grazing of livestock is commonly practiced in temperate Europe (Berendonk and Verhoeven, 2009). This land use system is based on the division of pastures in several smaller sections, while the grazing of livestock is limited to a single section (one after the other) for a period of days to weeks (Briske et al., 2008; Berendonk and Verhoeven, 2009; Undersander et al., 2014).

“Naturalistic grazing” on the other hand, is only applied since several years in Lower Oder Valley (Kraatz, 2017). Here, livestock grazing is integrated in the conservation concept of Lower Oder Valley National Park (Land Brandenburg, 2014). The underlying idea of “naturalistic grazing” is that livestock helps to maintain open landscapes by fulfilling ecological functions of large herbivore species, which originally occurred in the area but have become extinct (Vera et al., 2006).

When compared to rotational grazing, “naturalistic grazing” features lower livestock densities. As in “naturalistic grazing” livestock is subject to minimal management interventions and kept on the same pasture all year round, particularly robust livestock breeds are used for this land use system. The grazing system is argued to be particularly sustainable, which is promoted by a corresponding marketing strategy (Hodder and Bullock, 2009).

Thus, higher values regarding the analysed ecological parameters of wildlife communities were expected on the observed pasture adjacent to Lower Oder Valley National Park (“naturalistic grazing”), when compared to the rotation pasture in Havelland Nature Park.
However, despite the different protected area categories and grazing systems, the two German study areas reveal similar level of species richness and RCF patterns of wildlife. In both German study areas, the most frequently recorded wildlife species were roe deer (*Capreolus capreolus*) and red fox (*Vulpes vulpes*).

A further similarity of both study areas is that livestock presence was associated with significantly (Havelland) or highly significantly (Lower Oder Valley) lower RCF level of total wildlife and most of the recorded ungulate species. This finding from “naturalistic grazing” of livestock in Lower Oder Valley was not expected, since livestock grazing with low intensity is argued to be particularly suitable for biodiversity conservation (Tallowin et al., 2005; Dumont et al., 2007).

Unlike in Lower Oder Valley, livestock presence in Havelland was associated with 50% lower species richness of wildlife (Table 5). Consequently, it seems as if this reduction in species richness is an indicator for a higher degree of disturbance on rotation pasture in Havelland when compared to the “naturalistic grazing” in Lower Oder Valley. However, it has to be considered that the observed rotation pasture with livestock presence in Havelland represents only a small section of the grazing system. Here, livestock is absent on the major part of the pasture, where the species richness of the wildlife community is similar to pastures, directly bordering Lower Oder Valley National Park.

Another common pattern of the two German study areas is that most wildlife was recorded during night-hours. However, in contrast to Lower Oder Valley, livestock presence was associated with higher levels of wildlife activity during the night-hours in Havelland, when compared to the reference sites without livestock presence. Since wildlife activity during daylight can be an indicator for a low level of disturbance (McClennen et al., 2001; Mogensen et al., 2011; Rasmussen and Macdonald, 2012; Ramesh and Downs, 2013), livestock presence appears to have a positive effect on wildlife in Lower Oder Valley.

However, in Lower Oder Valley this finding can be explained by the generally low level of human activity associated with livestock presence. During the interview survey in the area hunters said, that they avoid entering the permanent pastures, since the kept cattle breed is particularly defensive. Furthermore, it has to be considered that roe deer and predators are not hunted inside Lower Oder Valley National Park (Schmutz and Vössing, 2009). Thus, the differences in the daily activity patterns of these wildlife species could result from different hunting pressure in both German study areas. It is known, that wildlife can shift its activity towards night-hours as response to hunting pressure induced by humans (Di Bitetti et al., 2008).

Electrified wires are used for fencing in both observed grazing systems in Germany to keep the livestock on the pastures. However, unlike in “naturalistic grazing” (Lower Oder Valley), wildlife disturbance through electrified wires and livestock presence is spatial and temporally limited a lot in rotational grazing (Havelland). Rotational grazing systems allow wildlife to use most of the pasture without disturbance through livestock and electrified fences all over the year. To conclude, the findings from the German study areas do not indicate a higher ecological value of “naturalistic grazing” when compared to the rotational grazing of livestock. The fact that wildlife was more active during day-hours on pasture associated with “naturalistic grazing”, appears to rather result from human absence than from livestock presence. It remains questionable, whether this positive effect of “naturalistic grazing” justifies the land use system, which is linked with an exclusion of other human activities.

4.1.4 Trans-regional comparison

The question was, whether there is a common response of wildlife (occurrence and activity patterns of ungulates and carnivores ≥ 4 kg) to livestock grazing in central Europe and sub-Saharan Africa and as the results of the camera trap surveys reveal, there are common wildlife response patterns to livestock grazing. In all four study areas, livestock grazing was associated with a significant or highly significant reduction of the total wildlife activity (RCF). A further common response pattern of various wildlife species to the grazing of livestock was a shift of the daily activity towards night-hours. These trans-regional similarities of the results indicate a general phenomenon. In contrast, the daily activity patterns of livestock reveal a region-specific difference. While in the German study areas, livestock showed permanent daily activity, a pronounced difference in livestock activity between day and night was observed in the African study areas.

In Africa livestock activity was mainly limited to daylight. This does not only count for Serengeti Region, where livestock is kept in bomas (livestock enclosures) during night-hours, but also for Etosha Region, where cattle was kept on pastures 24 hours a day. It can be assumed that the low level of livestock activity during night in Etosha Region is a response to predation risk associated with the occurrence of large carnivores. Large carnivore species are known to mainly hunt during night-hours (Hayward and Slotow, 2009). When compared to the study areas in Germany, a higher percentage of potential target species was observed in Etosha Region. This finding can be explained by the representativeness of the observed rangelands in relation to the different habitat types occurring in the respective study areas. While the observed rangelands in Namibia have a vegetation, which is commonly found in the reference area Etosha National Park, the observed grasslands in Germany represent only a small fraction of the habitat types occurring in Havelland and Lower Oder Valley.

It is known, that livestock grazing can have disturbing and dislocating effects on wildlife (e.g. Ogutu et al., 2009). However, in order to assess the response of wildlife to livestock grazing, the species level of wildlife has to be considered (Georgiadis et al., 2007). The comparison of European and African wildlife communities regarding species with similar ecological functions (Figure 52) reveals region-specific differences, but also common response patterns. A similar feature of European and African rangelands is the dominance of medium sized canids (e.g. red fox and black-backed jackal) among the group of carnivores. The fact that medium sized canids appear largely unaffected by livestock grazing can be explained by the broad ecological amplitude and the resulting adaptability to human activities. Several studies show that medium-sized canids can cope with the conditions in highly transformed landscapes, such as urban areas (Sillero-Zubiri and Stwizer, 2004; Bateman and Fleming, 2012; Mueller et al., 2018). In addition, suids seem to respond likewise to the grazing of livestock in central Europe and sub-Saharan Africa. In contrast to the less intense grazing systems (Lower Oder Valley and Etosha Region),

the more intense grazing systems (Havelland and Serengeti Region) reveal a pronounced decrease in the activity (RCF) of suids.

However, species that fulfil similar ecological functions in the wildlife communities of different geographical regions do not necessarily respond equally to the grazing of livestock. A region-specific difference was for instance found in the activity of small browsing ungulates. While the roe deer (*Capreolus capreolus*), was the most often recorded wildlife species in both German study areas, small browsers, like klipspringer (*Oreotragus oreotragus*) and steenbok (*Raphicerus campestris*) were recorded only sporadically in Etosha Region. The opposite was the case for larger ungulate species. While large ungulates (gemsbok [*Oryx gazella*], mountain zebra [*Equus zebra*] and greater kudu [*Tragelaphus strepsiceros*]) represent the most often recorded wildlife species in Etosha Region, the red deer (*Cervus elaphus*), was recorded only sporadically in Germany. This finding is not surprising, since several large wildlife species do not exist in European landscapes anymore (Benecke, 1999; Tokarska et al., 2011). Additionally remaining larger wildlife species face issues through habitat fragmentation (Schmölcke and Zachos, 2005; Salvatori and Linnell, 2005).

In contrast to the study areas in sub-Saharan Africa, no large carnivore was recorded in Havelland and Lower Oder Valley. However, camera trap data is not suitable to make statements about the absence of species (Rovero et al., 2010; Ancrenaz et al., 2012). Although not recorded, the wolf is confirmed to occur in the federal state of Brandenburg (Haferland, 2011). The results of the camera trap surveys represent only a spatial and temporal excerpt of the study areas (Yoccoz et al., 2001). Due to low capture probability, the detection of rare species usually requires more camera trap effort compared to species, occurring in high abundance (Tobler et al., 2008; O'Brien et al., 2011; Ancrenaz et al., 2012). Although camera trapping is referred to as non-invasive (e.g. O'Brien et al., 2011; Trolliet et al., 2014), species-specific differences in disturbance of wildlife during data collection must be considered (McCallum, 2013).

While in the German study areas no wildlife species was recorded, which is categorised by the IUCN Red List as endangered, vulnerable, near threatened, four vulnerable species (giraffe, mountain zebra, African elephant and leopard) could be proved in Etosha Region and one near threatened species (striped hyena) could be detected in the Serengeti Region. These records confirm that African rangelands have potential for the conservation of rare wildlife species (e.g. Barnard et al., 1998; Fynn and Bonyongo, 2011).

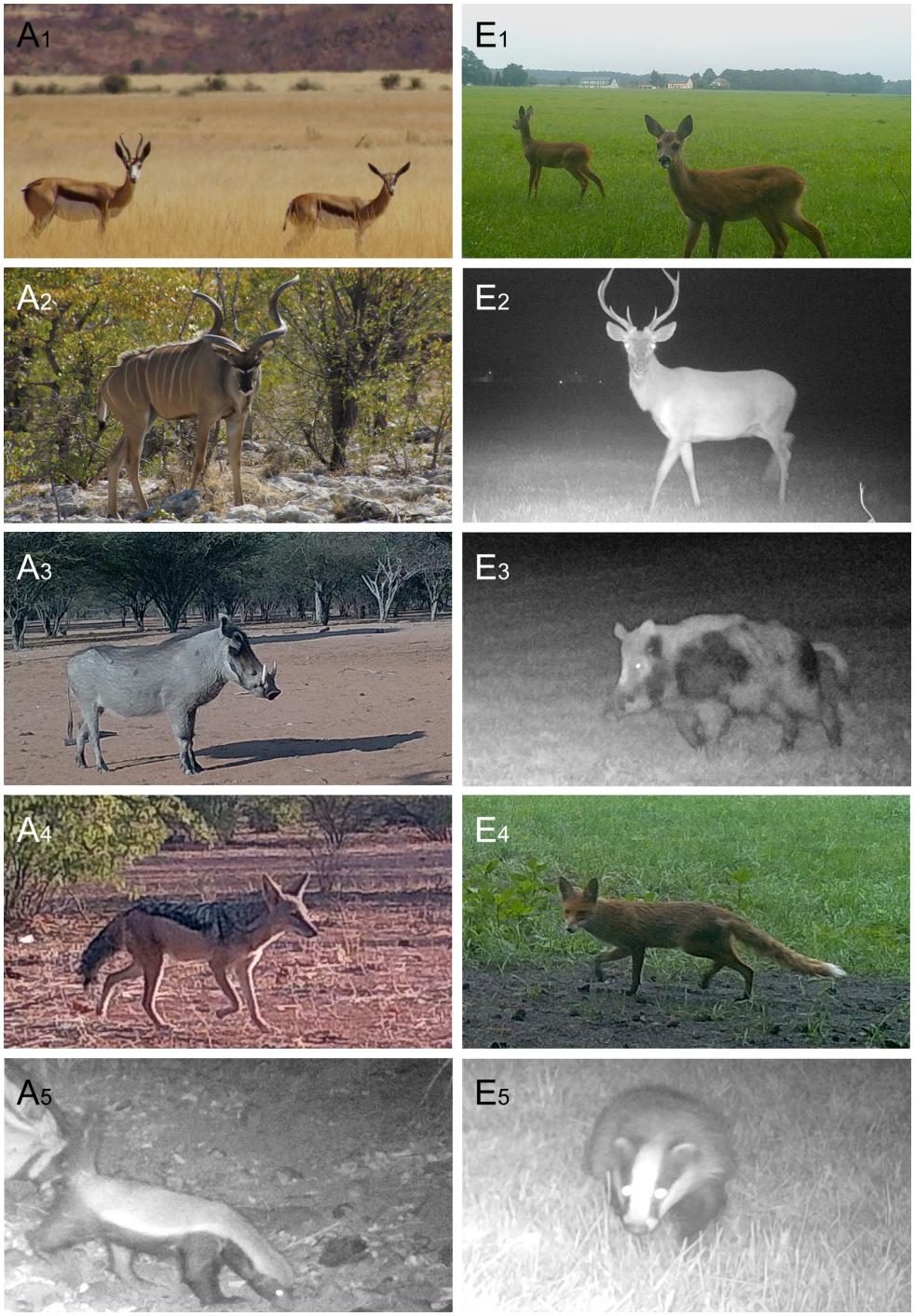

Figure 52: Camera trap photographs of comparable wildlife species in sub-Saharan Africa (left) and central Europe (right). A1: springbok (*Antidorcas marsupialis*) - E1: European roe deer (*Capreolus capreolus*); A2: greater kudu (*Tragelaphus strepsiceros*) - E2: red deer (*Cervus elaphus*); A3: common warthog (*Phacochoerus africanus*) - E3: wild boar (*Sus scrofa*); A4: black-backed jackal (*Canis mesomelas*) - E4: red fox (*Vulpes vulpes*); A5: honey badger (*Mellivora capensis*) - Eurasian badger (*Meles meles*). Figure adapted from Rottstock et al. 2020

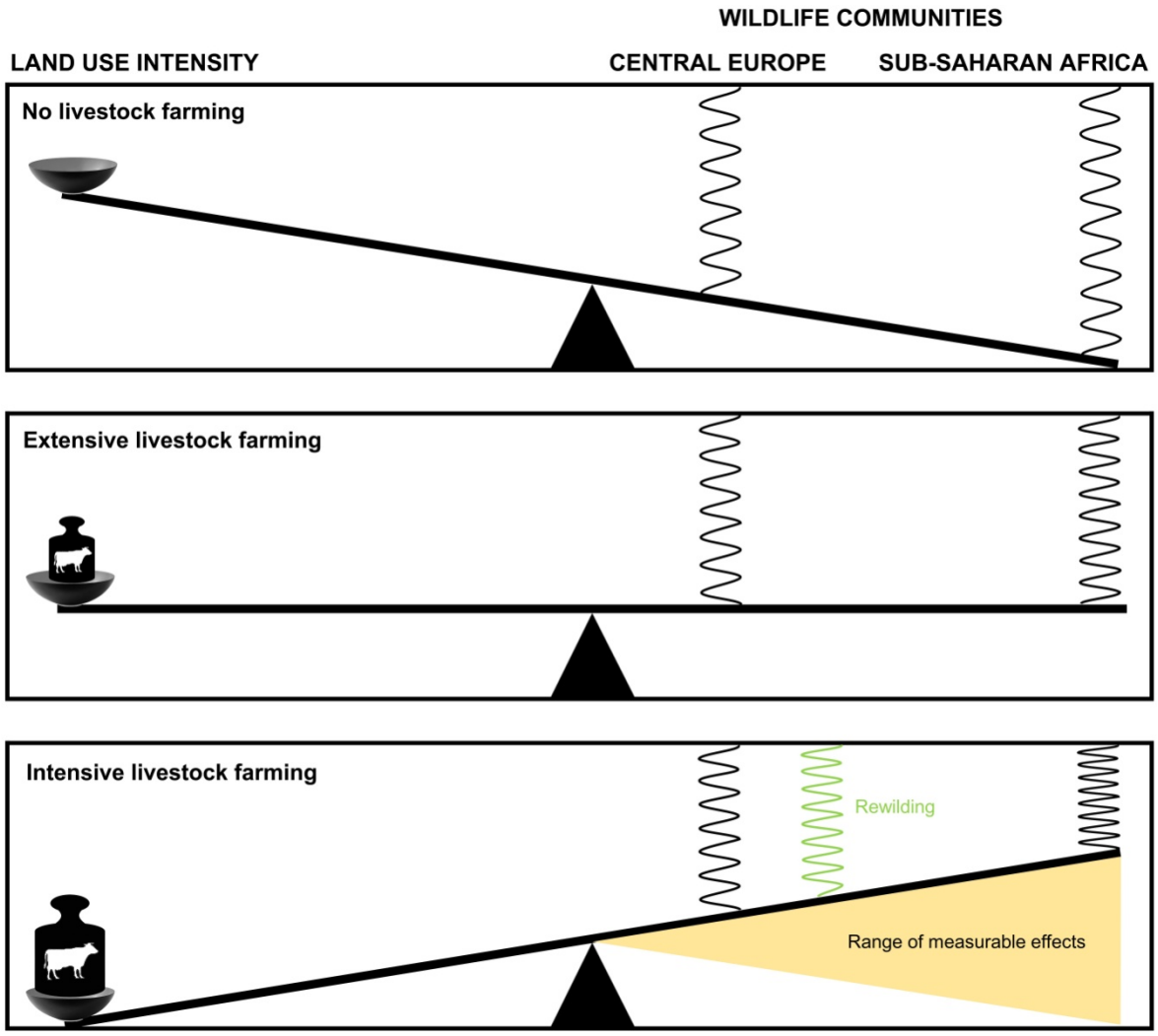

Figure 53: Transnational framework for the relation between the intensity of land use and its effects on wildlife communities in central Europe and sub-Saharan Africa. Figure adapted from Rottstock et al. 2020

On the basis of the findings from the four study areas, a framework was developed, which shows the relations between land use intensity and its impact on wildlife communities in central Europe and sub-Saharan Africa (Figure 53). Commonly, increasing land-use intensity leads to a decline in the measurable ecological parameters of wildlife communities in both geographical regions. The relevant ecological parameters, which in this case are associated with wildlife response to livestock grazing are: species richness, ungulate carnivore-ratio, total and species-specific RCF levels as well as activity patterns. Here, the term “organismic response scale” is used to describe changes in these ecological parameters of wildlife communities, while the symbol of a spring represents the wildlife communities of central Europe and sub-Saharan Africa. The “organismic response scale” of the wildlife communities is represented by the degree of compression (suspension travel) of the respective spring (Figure 53).

In contrast to sub-Saharan Africa, there is a relatively small “organismic response scale” in Europe (Figure 53). This indicates, that the response of wildlife communities to livestock grazing is much more pronounced in sub-Saharan Africa than it is the case for central Europe. It can be assumed that this also counts also for other human activities.

In sub-Saharan Africa, a comparable increase of land-use intensity results in a much stronger decline in the “organismic response scale” of the respective wildlife community when compared to central Europe. This region-specific difference in the impact of changes in livestock grazing intensity on the wildlife communities is related to the lower level of species richness in central Europe compared to sub-Saharan Africa (Varela et al., 2015). As the length of the two springs is associated with the diversity of the wildlife communities, the spring, representing the European wildlife community is shorter than the spring, illustrating the African wildlife community (Figure 53). Due to the considerably reduced wildlife community in Europe, here the range of measurable effects is not as broad as in Africa. A further factor, which is limiting the “organismic response scale” of wildlife communities in Europe, is related to the management practices associated with the grazing systems. For instance, a sustainable stocking rate is required in Europe in order to receive subsidies under the common agricultural policy of the EU (BMEL, 2019). Not only wildlife disturbance (Georgiadis et al., 2007) but also degradation of rangelands increases with the livestock density (Asner et al., 2004).

However, given different ecological conditions in central Europe and sub-Saharan Africa, a similar livestock density on communal managed rangelands in Africa (e.g. Serengeti Region) can already affect the habitat function. Overgrazing through livestock farming, is common in Africa and for instance associated with bush encroachment (Tobler et al., 2003). This phenomenon can be associated with declining habitat quality for wildlife (Augustine et al., 2011; Fynn et al., 2016). Livestock densities, which are suitable for European grasslands are far too high for African savannahs. In contrast to Europe several larger naturally occurring herbivore species compete with livestock over grasses in Africa. Consequently, similar RCF levels of livestock in Havelland and Serengeti Region indicate overstocking in the African study area. However, livestock grazing affects biodiversity not only through the stocking rate but also through different management practices, duration of grazing as well as kept species and breeds (Pavlu et al., 2003; Wrage et al., 2011). Thus, next to the region specific ecological carrying capacities of rangelands, different grazing systems in Europe and sub Saharan Africa influence the framework. Unlike the extremely devastating situation associated with agro-pastoralism in Serengeti Region, rotational grazing of livestock is applied on commercial farmland in Namibia (Mendelsohn et al., 2002). The rotational grazing of livestock has been practiced in Europe for more than 200 years and was introduced to Namibia during colonial times (Rothauge, 2001).

The relationship between land use intensity and its impact on wildlife communities in central Europe and sub-Saharan Africa (Figure 53) could make us believe that in central Europe, the impact of land use intensity is negligible compared to sub-Saharan Africa. It seems as if the European wildlife community responds insensitive to livestock farming and is not much affected by an increasing land use intensity. However, it has to be considered that in contrast to Africa the species richness of the stable-appearing European wildlife community has already been significantly reduced, when compared to the situation during Pleistocene. Several wildlife species, which are more sensitive to human interference are already extinct today. The unnatural state of the European wildlife community can explain the respective small response scale (Figure 53). Thus, the framework reveals that a meaningful assessment of the actual effects of livestock farming is not possible for the European wildlife community. However, the comparative interpretation of the findings from central Europe with the results from sub-Saharan Africa enables an impact assessment of livestock farming on the European wildlife community. Regarding the current trend of "rewilding" in European cultural landscapes, which includes the increase of the wildlife communities diversity (species richness), a larger “organismic response scale” is to be expected. Thus, additional conflicts particularly under high land use intensity are likely.

4.2 Problem-centred interviews

4.2.1 Practices with potential to improve the ecological sustainability of cattle grazing

Since biodiversity is essentially depending on the sustainability of farming practices (ELO, 2010) and sustainable use of natural resources (Griffin, 1998), the task was to identify management practices with potential to improve the ecological sustainability of cattle farming in sub-Saharan Africa. The results reveal that cattle grazing appears generally more sustainable in Europe, when compared to Africa. Contrary to results from study areas in Europe, findings from study areas in sub-Saharan Africa reveal ecological issues through unsustainable cattle grazing (Table 18). It is not a recent phenomenon that grazing of cattle is less sustainable in sub-Saharan Africa compared to temperate Europe (Zeuner, 1963). Similar to the results from the camera-trap surveys, findings from the social science approach reveal a special situation of Serengeti Region, where livestock farmers put the lowest effort in the sustainability of cattle farming, when compared to the other study areas.

Bush encroachment is a widespread phenomenon in African savannas (e.g. Trollope, 1982; Mendelsohn et al., 2002; Ward, 2005; Sinclair et al., 2008; Otuoma et al., 2009). Next to heavy livestock grazing (e.g. Tobler et al., 2003; Asner et al., 2004; Coetzee et al., 2008), bush encroachment is thought to be caused by low abundance of native browsing herbivores, low frequency of fires (Dublin, 1995; Scholes and Archer, 1997; Augustine et al., 2011; O'Connor et al., 2014) and climatic changes (Asner et al., 2004; Morgan et al., 2007). Consequently, diverse factors (fire, ungulates and competition through grasses) are known to potentially counter the spread of woody vegetation (e.g. Dublin, 1995; Sharam et al., 2006). Although burning has been traditionally used to maintain rangelands (e.g. Dublin, 1995; Homewood, 2008; Fynn et al., 2015), fire is not part of pasture management of farmers in either study area (Table 18). The interviewees mentioned two reasons. On the one hand, there is the risk that fires run out of control (Mendelsohn et al., 2002), while effective fires, on the other hand, require high amounts of dry grasses, which are limited due to intensive grazing (Dublin, 1995; Sinclair et al., 2008).

Given the region specific ecological impact of cattle farming, one would assume that grazing management from Europe can improve the less sustainable situation in sub-Saharan Africa. The results from Etosha Region are rather similar to the study areas in Germany than to Serengeti Region. This is not surprising, since the grazing system applied by commercial farmers in Namibia is strongly related to European rotational grazing (Rothauge, 2001). Namibia was a German protectorate from 1884 and former German colony between 1890 and 1915 (Mendelsohn et al., 2002). Since colonial times, there has been a transfer of cattle breeds (Figure 4) and management practices from Europe towards Africa (Rothauge, 2001), where introduced rotational grazing of cattle (common on commercial land) can be found next to traditional and altered pastoral grazing (common on communal land).

4.2.1.1 Stocking rates adapted to the rangelands' carrying capacities

Whereas farmers in Etosha Region and Germany reduce the number of cattle at the end of growing seasons, and thus adapt livestock quantities to the available pasture, this was not the case in Serengeti Region (Table 18). Although the European example reveal that sustainable grazing requires stocking rates adjusted to the available pasture (Rosenthal et al., 2012), African pastoralists habitually aim to own high livestock numbers. This behaviour can be explained by immense cultural value of cattle in pastoral societies (Figure 45; Doran et al., 1979; Milner-Gulland and Bennett, 2003; Olff and Hopcraft, 2008; Sinclair et al., 2008). Its high cultural value makes livestock a popular source of investment; given tribal bonds also for people, which have previously moved to urban areas (McPeak and Little, 2005; BurnSilver, 2009). However, in combination with rapid human population growth, high cultural value of livestock leads to overstocking, which has negative impact on wildlife and vegetation, particular during droughts (e.g. Ogutu et al., 2009). High livestock density can have similar disturbing effects on wildlife presence as it is the case for fences (Georgiadis et al., 2007; Hobbs et al., 2008; Durant, 2017).

"*Many of the ecological concepts developed in the temperate zones fail to explain the dynamics of these highly variable ecosystems*" in Africa (Little, 1996 p.38). For instance the concept of carrying capacity was never part of pastoralism (Little, 1996) and should not be simply transferred to arid and semi-arid savannas with high climatic variability (unpredictable rainfalls) in order to evaluate the sustainability of livestock farming (Homewood and Rodgers, 1984; Scoones 1989; Mendelsohn et al., 2002; Hobbs et al., 2008). Agro-pastoralism, as common land use system in Serengeti Region (Sinclair et al., 2008; Mwakatobe et al., 2013) originates from traditional African pastoral lifestyle (Bromage and Schrenk, 1999; Reader, 1999; Lynn, 2010; Degen, 2011). Cattle pastoralism is a traditional African land use strategy (Brierley et al., 2018), supposed to be at least 8,000 years old (Wendorf and Schild, 1994; Gabriel, 2002). Traditional African grazing management (pastoralism) has developed in adaptation to local environmental conditions - husbandry practices developed in other geographical regions are not necessaryly suitable to counter ecological issues in Africa (Nyerges, 1982). Traditionally livestock numbers in Africa were limited through droughts and diseases (Smith, 2005; Brierley et al., 2018). However, veterinarian services have improved (Bengis et al., 2002; Kock et al., 2010) and numerous artificial waterholes have been established in Africa, leading to ungulate densities above savannas' resilience and associated land degradation (Berry, 1997; Mendelsohn et al., 2002).

There is a relation between cattle density and degradation of rangelands in Africa (Bourne, 1978). The particularly high cattle stocking density in Serengeti Region (Figure 47) indicates unsustainable livestock grazing. Consequently, there is a desire to reduce livestock numbers and associated grazing pressure on communally managed African rangelands. This is not only important in seasons and during droughts but also in years with above-average rainfall, to allow for more competition between bushes and grasses

(Ward, 2005). Seedlings of woody plant species particularly benefit from wet dry seasons and absence of fire (Sinclair et al., 2008). Next to fundamental change in mindset of livestock farmers limiting government policies and improved markets for livestock are required (Sinclair et al., 2008).

In the African context, flexible land use management is crucial to cope with changes (e.g. avoid overstocking) (McAllister et al., 2006; Galvin, 2009; Notenbaert et al., 2012). Changing ecological conditions also require flexible strategies in wildlife management (Barrows et al., 2005).

4.2.1.2 Livestock mobility

Similar to the rotational grazing of cattle, which is originating from Europe (Rothauge, 2001) and comprises regular livestock mobility through rotation of cattle between several paddocks (Mendelsohn et al., 2002; Berendonk and Verhoeven, 2009), traditional African pastoralism is based on seasonal movement according to the availability of resources (e.g. Olff and Hopcraft, 2008; Augustine et al., 2011; Macandza et al., 2012; Notenbaert et al., 2012; Fynn et al., 2016; Tyrrell et al., 2017).

Livestock mobility contributes to the sustainability of grazing systems in different ways. On the one hand, it can avoid degradation of rangelands through overgrazing, as it allows the vegetation to recover (Niamir-Fuller, 1999; Ash et al., 2004; Hobbs et al., 2008). Grazing systems which comprise livestock mobility also allow for higher stocking rates (Pavlu et al., 2003; Wrage et al., 2011), associated with less selective grazing (Hart, 2001, Pavlu et al., 2003; Dumont et al., 2007). On the other hand, livestock mobility can reduce competition for resources between livestock and wildlife (Voeten and Prins, 1999; Little, 1996; Ash et al., 2004; Galvin, 2009; Fynn et al., 2016; Schuette et al., 2016) and thus, support native herbivores (e.g. Augustine, 2004; Ogutu et al., 2005). Additionally, livestock mobility reduces the risk of livestock infection by wildlife-carried diseases (Homewood and Rodgers, 1984; Schuette et al., 2016).

The results from the Etosha Region reveal, that rotational grazing developed under European conditions can also be applied in sub-Saharan Africa, which however is not necessarily sustainable under the different ecological conditions (Hawkins et al., 2017). Interviewed farmers from Etosha Region said, that rotational grazing practices cannot be adequately applied during droughts. Farming in sub-Saharan Africa depends on reliable rainfall (Mendelsohn et al., 2002; Sewando et al., 2016). It has to be considered that different climatic conditions in central Europe and sub-Saharan Africa affect the sustainability of livestock farming. While the growing season in temperate latitudes is limited due to cold winter, in African savannas it is limited due to dry-seasons (Knapp et al., 2006).

Although crucial for sustainable livestock farming in semi-arid African savannas (e.g. Niamir-Fuller, 1999; Galvin, 2009; Neely et al., Homewood, 2008; 2009; Fynn et al., 2016; Tyrrell et al., 2017), livestock mobility identified in Serengeti Region is low when compared to other study areas (Figure 48). The results reveal a grazing system, which has little in common with the historically grown pastoralism, often described as a sustainable land use strategy (e.g. Niamir-Fuller, 1999; Homewood, 2008). The surrounding of SNP faces high pressure through fast human population growth and change of traditional land use (e.g. Arcese et al., 1995; Walpole et al., 2004; Olff and Hopcraft, 2008; Sinclair et al., 2008; Ogutu et al., 2009; Ukio, 2010). There is a trend of sedentarization among African pastoralists and consequently decreasing livestock mobility (e.g. McPeak and Little, 2005; Little et al., 2008; Galvin, 2009). Settlements and related human activities cause increasing pressure on African ecosystems (e.g. Olff and Hopcraft, 2008; Sinclair et al., 2008; Harris et al., 2009; Ogutu et al., 2009; Otuoma et al., 2009). Both, wildlife and pastoralism depend on extensive and heterogenic rangelands (e.g. Niamir-Fuller, 1999; Owen-Smith, 2004; Galvin, 2009; Fynn et al., 2016; Durant, 2017), particular important during droughts (e.g. Ogutu and Owen-Smith, 2003; Durant et al., 2015). However, land use changes and associated fragmentation of rangelands lead to increased interactions like for instance competition between livestock and wildlife (e.g. Otuoma et al., 2009; Groom and Western, 2013; Fynn et al., 2016). Moreover, this development threatens wildlife and pastoralism (e.g. Homewood et al., 2001; Milner-Gulland and Bennett, 2003; McAllister et al., 2006; Western et al., 2009; Groom and Western, 2013; Tyrrell et al., 2017).

Several studies indicate that policy changes have potential to improve the sustainability of pastoralism (e.g. Hobbs et al., 2008; Notenbaert et al., 2012). Sedentarization of former pastoralists and fragmentation of rangelands are frequently policy-driven (e.g. Western et al., 2009). The mobility of pastoralists is often restricted through the establishment of protected areas (Homewood et al., 2009; Kabiri, 2010). However, people also appreciate socioeconomic benefits associated with a sedentary lifestyle (Fernandez-Gimenez and Le Febre, 2006; Hobbs et al., 2008). Given the diverse mentioned advantages, livestock mobility might be the key for coexistence between livestock and wildlife (Schuette et al., 2016; Tyrrell et al., 2017) not only in the Serengeti Region.

4.2.1.3 Integration of livestock grazing into conservation concepts

Naturally occurring herbivores have a strong impact on the vegetation of African savannas (e.g. Cumming, 1982; Dublin, 1995; Du Toit and Cumming, 1999; Sinclair et al., 2008). In particular elephants (Dublin, 1995; Morrison et al., 2016) and further native browsers are important to keep African savannas open (e.g. Mendelsohn et al., 2002; Augustine et al., 2011). Cattle farming can lead to bush-encroachment when wildlife is excluded from the rangelands (Tobler et al., 2003; Augustine et al., 2011). However, wildlife farming can lead to bush encroachment as well, when burning is excluded (Georgiadis et al., 2007). Thus, it is particularly effective to combine fire with the activities of browsing herbivores (Dublin, 1995; Augustine et al., 2011; O'Connor et al., 2014).

In contrast to the study areas in sub-Saharan Africa, landscaping is an important motive for grazing of cattle in Europe (chapter 1.1), and integrated in protected area management in both German study areas (Figure 45; Table 18). While cattle farming is often made responsible for land degradation in Africa (e.g. Zeuner, 1963), in the European context, grazing of livestock (domesticated herbivores) commonly fulfils ecosystem services (e.g. Paracchini et al., 2008; Rosenthal et al., 2012) as partly replacing the ecosystem shaping function of the decimated naturally occurring herbivores (Vera et al., 2006). As not only overgrazing, but also undergrazing can have negative impact on rangelands (Hart, 2001), there is a desire to involve traditional farming practices into conservation concepts, in order to preserve cultural landscape and associated biodiversity in Europe (ELO, 2010).

However, there are positive examples of both, confined and guided grazing, which reveal that the combination of cattle farming and wildlife management is possible in the African context. The camera trap survey from the Etosha Region for instance shows a potential of mixed farming on private land for wildlife conservation (chapter 4.1.2). Next to the government owned protected area network (PAN) there is a variety of privately managed game farms and nature reserves which contribute to biodiversity conservation (Barnard et al., 1998; Griffin, 1998; Mendelsohn et al., 2002; Barnes and Jones, 2012). Unlike livestock farms, game farmers perceive large predators not necessarily as a threat and can thus, contribute to their preservation (Göttert and Zeller, 2008). However, as the results show, this often causes conflict between neighbouring farms. Jointly managed conservancies have potential to improve the attitudes towards conflicting wildlife species like carnivores on commercial rangeland in Namibia (Schumann et al., 2008; Lindsey et al., 2013).

Originally, pastoral livestock farming is not unsustainable (e.g. Behnke, 1994) and can even facilitate biodiversity (e.g. Homewood and Rodgers, 1984; Western and Gichohi, 1993; McGahey et al., 2008; Neely et al., 2009; Norton-Griffiths and Said, 2010; Augustine et al., 2011; Fynn et al., 2016; Tyrrell et al., 2017). Wildlife populations can be higher on adjacent pastoral land than in protected areas (ILRI, 2006). Some scientists argue that African savannas depend on pastoralism (Little, 1996; Niamir-Fuller, 1999). Excluding

pastoralists from rangelands can have negative effects on biodiversity as well (Lamprey and Wallner, 1990). We have to be aware that African savannas have been influenced by pastoralism over millennia and should not be recognised as natural wilderness (Little, 1996). A good example is the Ngorongoro Conservation Area in Tanzania, where Maasai pastoralists graze cattle peacefully next to wildlife (e.g. Thirgood et al., 2004; Olff and Hopcraft, 2008). During the last 5,000 years, human activities (e.g. burning, livestock husbandry and cultivation) have had strong impact on this landscape (Olff and Hopcraft, 2008).

The European approach of restricted livestock grazing in protected areas might have potential to smoothen conflicts (e.g. as identified at SNP). A potential of integrated management (incorporation of livestock farming into conservation concepts) in the African context is also mentioned in previous studies (e.g. Niamir-Fuller, 1999; Augustine et al., 2011; Notenbaert et al., 2012; Ogutu et al., 2016; Tyrrell et al., 2017). However, given sensitive savanna ecosystems restrictions for livestock farming are crucial when integrated in conservation management. While benefits from conservation biodiversity for local communities are often monetary (Victurine and Curtin, 2010), controlled access to pasture for livestock in less sensitive parts of protected areas can also mitigate conflicts between farmers and conservationists, particularly during dry season (Fynn et al., 2016). Livestock-wildlife interactions can also be facilitative so that cattle and native ungulates can benefit each other (Homewood and Rodgers, 1984; Norton-Griffiths and Said, 2010; Augustine et al., 2011; Odadi et al., 2011; Fynn et al., 2016). Grazing of livestock can for instance be used to create firebreaks inside protected areas (Fynn et al., 2016).

There is the approach of community-based conservation on communal land in sub-Saharan Africa, argued to facilitate sustainable use of resources and coexistence of livestock farming and wildlife through socioeconomic benefits from tourism (Barnard et al., 1998; Mendelsohn et al., 2002; Milner-Gulland and Bennett, 2003; Thirgood et al., 2004; Nelson, 2008; Sinclair et al., 2008; Naidoo et al., 2016; Schuette et al., 2016; Tyrrell et al., 2017). However, degradation of rangelands in respective conservation areas (wildlife management areas) was mentioned by interviewees from Serengeti Region and described by Glew et al. (2010). Community-based conservation rarely appears to be successful (Adams et al., 2004).

An obvious lack of benefit sharing from conservation (protected areas) was identified in sub-Saharan Africa (Table 16). This issue is mentioned in several previous studies (e.g. Okello, 2005; Nelson, 2008; Homewood et al., 2009; Kabiri, 2010; Norton-Griffiths and Said, 2010). Poverty is common and increasing in pastoral societies (Homewood, 2008), known to contribute to unsustainable use of natural resources (Little et al., 2008) and related threat to biodiversity (Adams et al., 2004). Local people in communally managed areas need alternative ways of income apart from livestock farming (diversification) in order to be able to reduce the number of livestock (Notenbaert et al., 2012).

Sedentarization offers possibilities for income diversification, of which crop cultivation has become important for pastoral livelihoods (Otuoma et al., 2009, Notenbaert et al., 2012). However, sedentarization has negative effects on wildlife at the same time (Western et al., 2009). Although alternative ways of income are thought to counter overexploitation of natural resources (e.g. DeFries et al., 2007), agro-pastoralism can be assumed not to be a sustainable alternative. Crop-farming is known to have more negative effects on wildlife than pastoralism (Homewood and Rodgers, 1984; Little, 1996; Olff and Hopcraft, 2008; Galvin, 2009; Otuoma et al., 2009; Notenbaert et al., 2012; Fynn et al., 2015). Protected areas can generate income through Ecotourism (e.g. Wells et al., 1992; Charnley, 2005; EEA, 2012). Related socio-economic benefits have potential to support livelihoods of local people, and their acceptance of conservation methods (e.g. Wells et al., 1992; Milner-Gulland and Bennett, 2003; Okello, 2005; Nelson, 2008; Norton-Griffiths and Said, 2010; EEA, 2012; Child, 2014). In combination with ecotourism, pastoralism has a potential for conservation (Notenbaert et al., 2012).

In contrast to Africa, farmers from study areas in Germany receive subsidies for sustainable land use (e.g. restrictions through conservation). In Europe, conservation of biodiversity and sustainable use of natural resources are part of the agricultural policy (ELO, 2010; EEA, 2010). Here, sustainable livestock grazing depends on associated financial support (Jedicke and Metzner, 2012). However, subsidies for more sustainable farming can be assumed to be ineffective on communally managed rangelands in sub-Saharan Africa, where livestock has immense cultural value, for instance as a substitute for bank accounts and insurances (Milner-Gulland and Bennett, 2003).

4.2.1.4 Harvest of forage during growing season

The results reveal that unlike interviewed farmers in Germany, which harvest forage during growing season to offer during times of shortage, farmers from study areas in Africa mostly use the entire available rangeland for livestock grazing (Figure 48). The mowing of rangelands is beneficial for conservation of biodiversity in European grassland ecosystems (Tallowin et al., 2005; Wrage et al., 2011; Rosenthal et al., 2012). In contrast to farmers from all other study areas, agro-pastoralists in Serengeti Region do not offer additional fodder to their livestock during times of shortage. Pastoral grazing management does not comprise inputs to improve animal conditions during droughts but rather depend on extensive grazing land to buffer shortages (Hobbs et al., 2008; Notenbaert et al., 2012; Fynn et al., 2015). Most interviewed cattle farmers from Etosha Region use young bushes to produce feed for their livestock during drought. As the production of "bush fodder" requires external inputs (Gouws, 2017), this practice can be assumed to be unsuitable for subsistence farming on commercial land. However, harvest and storage of forage during vegetation periods based on the European model could reduce grazing pressure during times of shortage and thus increase the sustainability of cattle farming on African rangelands.

4.2.1.5 Fencing of pastures

Similar to the study areas in Germany, fences are used for grazing of cattle by all interviewed farmers in Etosha Region. In contrast, none of the interviewees from Serengeti Region applied fences on the rangelands. Whereas confined grazing (use of fences) is common in Europe and on commercial farms in Africa (Rothauge, 2001; Mendelsohn et al., 2002; Berendonk and Verhoeven, 2009), attended grazing (herding) is practiced on communally managed African rangelands (Augustine et al., 2011). Pastoralists, as for instance Maasai do not use fences for livestock grazing (Sinclair et al., 2008). This finding can be explained by the different forms of land tenure. In the African context, change of land tenure from communally managed land to private land is often associated with construction of fences (Kristjanson et al., 2002; Reid et al., 2004).

Since this development frequently causes fragmentation of rangelands in Africa (e.g. Reid et al., 2004; McAllister et al., 2006; Galvin, 2009), it would interfere with regional conservation goals in the Serengeti Region, such as the protection of wildlife long-distance movements in response to seasonal availability of resources ("Great Migration") (Løvschal et al., 2017). Quite the opposite, Etosha National Park is enclosed with a high fence to keep the wildlife inside the protected area (Berry, 1997). Although often used to mitigate HWC, fencing of protected areas appears to be unsuitable for wildlife conservation; wildlife depend on migration according to seasonal availability of resources and genetic exchange between isolated populations (e.g. Gasaway et al., 1996; Berry, 1997; Massey et al., 2014; Trinkel et al., 2017).

Additionally, so-called veterinary cordon fences aim to prevent infections of livestock by wildlife carried diseases in southern Africa to meet European trade regulations for livestock products (e.g. Thomson et al., 2013; Durant, 2017). Although there are various diseases on the African continent, which can be transmitted between wildlife and livestock (Kock et al., 2010), as for instance foot-and-mouth disease (Bengis et al., 2002), this was not an issue for any of the interviewed livestock farmers. Such game-proof fences are known to cause high mortality of migrating ungulates in Africa (e.g. Harris et al., 2009; Gadd, 2012; Durant, 2017). Not only are they controversial from a ecological perspective but also from a social one (e.g. Brooks et al., 2011; Kamuti, 2014). Consequently the necessity of the veterinary fences can be questioned in times of improved veterinarian services.

Results from these three study areas reveal that disturbance of wildlife increases with the quantity of wires. A relation between the number of wires in cattle farming and the level of wildlife disturbance was also observed by Karhu and Anderson (2006). However, the findings from Serengeti Region show that grazing of cattle without fences, but human herders, is not necessarily good for wildlife either. The results from Etosha Region show that cattle fences are usually not electrified and cause much less disturbance to wildlife compared to high game fences.

4.2.1.6 Rewilding

Despite intensive anthropogenic transformation and infrastructural fragmentation of European landscapes (EEA, 2012), there is a recent trend of "rewilding" in conservation (Trouwborst, 2010; Helmer et al., 2015). In this context, some incorrectly used terminology should be clarified. It is not only the term "wilderness", which is confusingly used to assess anthropogenic transformed European ecosystems (Fisher et al., 2010) and to categorise associated protected areas by the IUCN (EEA, 2012). It seems as conservationists promote unreal "wilderness" to generate income. Grazing of livestock is argued to be the most suitable land use strategy for less disturbed grassland ecosystems (Wrage et al., 2011). Historical processes of agricultural development reveal that traditional farming practices can increase biodiversity (ELO, 2010). However, conservationists have introduced a new grazing system ("naturalistic grazing") in Lower Oder Valley (Schalitz, 2011; Vössing, 2012; Vössing, 2015). This grazing system has not much in common with the traditional rotational grazing of livestock in the region. The permanent grazing is less labour-intensive compared to rotational grazing (Wrage et al., 2011). The role model of "naturalistic grazing" is the protected area Oostvaadersplassen in the Netherlands, where red deer and livestock (Heck cattle and Konik horses) are kept in an enclosure (Hodder and Bullock, 2009; Theunissen, 2019). Livestock in this context is supposed to replace the ecosystem shaping function of their extinct stem-species (Vera et al., 2006). However, the objective of the project is questioned (Hodder and Bullock, 2009) and the approach criticized, as fenced animals are dying from starvation (Theunissen, 2019).

While people in the observed study areas in sub-Saharan Africa clearly distinguish between domestic animals and wildlife (and associated management) this is not always the case in Europe (Lower Oder Valley). For instance, the term aurochs (*Bos primigenius*) is misleadingly used (scientifically incorrect) for marketing of Heck cattle (*Bos primigenius* f. taurus) and associated products. Heck cattle goes back to breeding trials of the brothers Lutz and Heinz Heck (directors of zoos of Berlin and Munich) during German National Socialism, aiming to re-establish the by 1627 extinct aurochs (*Bos primigenius*) (Zeuner 1963). However, despite similar phonotypical characteristics, Heck cattle is clearly different to the stem species (e.g. Van Vuure, 2002). As there is an obvious difference between the two processes of domestication and evolution, it should be clearly distinguished between "stem species" and "domesticated forms" (Herre and Röhrs, 1990; Zeller and Göttert 2019). For the purpose of landscaping, the cattle breed is negligible (Dumont et al., 2007). There are several traditional breeds, which are endangered (e.g. Taberlet et al., 2008; FAO, 2016) and thus should be considered for conservation projects. Although browsing ungulates are essential to counter the spread of woody vegetation in particular (e.g. Dublin, 1995; Mendelsohn et al., 2002; Augustine et al., 2011; O'Connor et al., 2014), grazing domesticated herbivores (cattle and horses) are exclusively kept in Lower Oder Valley. Next to the camera trap survey, also the interviews from Lower Oder Valley reveal that "naturalistic grazing" has considerable impact on

wildlife presence. The grazing system is based on the so-called mega herbivore theory (Vera et al., 2006). Thus, it would make more sense to support the remaining native and partly endangered natural occurring larger herbivores (e.g. moose [*Alces alces*], European bison [*Bos bonasus*] and red deer [Cervus elaphus]) as it is the case on commercial farmland in Namibia, instead of keeping domesticated herbivores and incorrectly marketing them as extinct stem species.

Interviewees from both study areas in Germany say that in rotational grazing, wildlife is present on the pasture when cattle is absent. Rotational grazing typically consists of short grazing periods with a moderate livestock density on a portion of the pasture, followed by long periods for re-growth of pasture (Berendonk and Verhoeven, 2009; Wrage et al., 2011). As rotational grazing is limited to the vegetation period in Europe, there is no interaction with wildlife during winter (time of shortage). It is confirmed that moderate intense rotational grazing has highest potential to benefit biodiversity in temperate regions (Wrage et al., 2011). Thus, rotational grazing appears to be better for wildlife compared to "naturalistic grazing". The results from the study areas in Germany reveal that sustainable grazing requires management adjusted to the specific ecological site conditions and biodiversity conservation targets (Rosenthal et al., 2012).

4.2.2 Preservation of traditional cattle breeds

Since a high genetic diversity in livestock breeds is important for future breeding and at the same time several traditional breeds are endangered (e.g. Taberlet et al., 2008; FAO, 2016), the question was how important do farmers in central Europe and sub-Saharan Africa consider the preservation of traditional cattle breeds.

A higher variety of cattle breeds was kept by livestock farmers in Germany, when compared to the study areas in Africa (Table 15). This finding can be explained by region specific differences in livestock breeding. While systematic breeding has led to several specialized breeds in Europe (Porter, 1991; Felius, 1995; Bradley et al., 1998), there is usually no documentation in the African context (Ajmone-Marsan et al., 2010). Traditionally selection of cattle is rather based on morphological characteristics than related to production in Africa (Porter, 1991). Small stock is kept more often next to cattle by interviewed farmers from Tanzania and Namibia when compared to study areas in Germany (Table 15). This finding can be explained by the higher risk of droughts in Africa, favouring smaller livestock (sheep and goats) instead of cattle (Seo and Mendelsohn, 2006). As goats are browsers, they can also benefit from bush encroachment (Fynn et al., 2016).

Serengeti Region was the only study area, where preservation of traditional cattle breeds is perceived as highly important by livestock farmers (Figure 46). Here, the interviewed agro-pastoralists exclusively keep Tanzanian Shorthorn Zebus (TSZ), also described by Komwihangilo et al. (2009). This finding can be explained by the different motives of cattle

farming compared to the other study areas (Figure 45). Commercial cattle farming, as practiced in the other three study areas, is typically associated with high performance breeds instead of lower yielding traditional breeds (Felius, 1995; Yarwood and Evans, 1999; Figure 46). However, in pastoral systems like the Serengeti Region, cattle has a high cultural value; quantity of cattle is most important, as related to the owner's prestige (Milner-Gulland and Bennett, 2003). Furthermore, recently introduced breeds are often referred to as exotic breeds (Ogutu et al., 2009) and turn out to be insufficiently adapted to the tropical environment (Bartha, 1971; Felius, 1995; FAO, 2007) and unsuitable for poor traditional African livestock management (Porter, 1991).

In contrast to Serengeti Region, interviewed farmers from Etosha Region mainly cross indicine cattle with taurine breeds from Europe (Table 15). This is done to combine the advantages of both domestic forms (Bartha, 1971). Crossbreeding can be seen as a compromise between better adaptation to tropical climate (*Bos primigenius* f. indicus) (Bartha, 1971; Grigson, 1991) and large bodies, demanded by the beef industry (*Bos primigenius* f. taurus) (Scholtz et al., 2008). Whereas historical Sanga cattle is more similar to taurine cattle, modern Sanga breeds often reveal strong zebu influence (Grigson, 1991; Felius, 1995; Hanotte et al., 2000). Although mainly practiced by Europeans (Porter, 1991), crossbreeding of local cattle with higher yielding breeds from other regions is recently practiced in communal African cattle farming as well, to improve the performance (BurnSilver, 2009). This is also the case for the TSZ (Komwihangilo et al., 2009).

However, crossbreeding does not only promise more profit, it also offers the risk of losing the traditional African cattle, which is particularly well adapted to the extreme environmental conditions (BurnSilver, 2009). The importance to preserve traditional African cattle is also stressed by Das and Mkonyi (2003). There are about 150 local African cattle "breeds" (Rege et al., 1996; FAO, 2007), representing a vital genetic reservoir for future breeding not only in the African context (Hanotte et al., 2000).

4.2.3 Comparison of stakeholder functions

Although livestock farmers and conservationists habitually have different management goals, cooperation between these stakeholder groups is beneficial for biodiversity (Wrage et al., 2011). Furthermore, hunting is usually applied to mitigate conflicts between farming and conservation (e.g. Boitani and Moehrenschlager, 2004; Schmutz and Vössing, 2009; Kompaniyets and Evans, 2017). Consequently, the question was to what extend stakeholder functions (cattle farming, wildlife conservation and hunting) differ in central Europe and sub-Saharan Africa. In contrast to the other study areas, functions of interviewees are less diverse in Serengeti Region (Figure 50). The fact that interviewees focus either on cattle farming or wildlife conservation could explain the particularly unsustainable use of resources by livestock farmers. This could for instance explain the

relatively high level of human-wildlife conflict (HWC) in the Serengeti Region when compared to the other study areas (Figure 51). HWC is usually based on different management goals of stakeholder groups (Clark et al., 2014; Redpath et al., 2015).

Figure 50 also shows that in contrast to all other study areas, where hunting of wildlife is a common strategy to mitigate HWC, official hunting is not practiced in the Serengeti Region. There is intensive hunting of wildlife in the protected areas associated with the study areas in Germany, including strictly protected parts of Lower Oder Valley National Park, to mitigate HWC with neighbouring farmers (Schmutz and Vössing, 2009). In Europe, protected areas and hunting are closely related since feudal times (EEA, 2012). The example of LOV shows that certain wildlife species, which are not allowed to be hunted (roe deer and carnivores), consequently cause conflict (Schmutz and Vössing, 2009). Similar to the study areas in Germany, hunting of wildlife is commonly practiced on commercial farms in Namibia (Griffin, 1998; Mendelsohn et al., 2002; Göttert and Zeller, 2008). First hunting regulations in Namibia were set up under German administration for more sustainable use of wildlife in 1892 (Barnard et al., 1998). Since the ownership of wildlife and thus the economic value was given to the owners of commercial farms in 1967, wildlife is managed more sustainable on private land (Griffin, 1998; Mendelsohn et al., 2002; Göttert and Zeller, 2008). Consequently, the special situation in the Serengeti Region (particularly unsustainable use of resources) is probably also related to the different forms of land tenure. In contrast to all other study areas, farmland in the Serengeti Region is communally managed. The communal land is owned by the government and local authorities, but not by the communities (Mendelsohn et al., 2002). However, similar initiatives like on private farmland failed on communally managed land in Namibia, where poaching is a common threat to wildlife populations (Griffin, 1998). Poaching of wildlife is common in Serengeti Region as well (e.g. Dublin et al., 1990; Loibooki et al., 2002; Kaltenborn et al., 2005; Olff and Hopcraft, 2008), where small-scale subsistence farming is dominating and wildlife is commonly perceived as pest (Olff and Hopcraft, 2008). The experience from Namibia reveals that high cultural value of livestock farming hampers acceptance of wildlife and a shift towards game farming, despite potential for biodiversity conservation and tourism related incomes (Göttert and Zeller 2008).

There is a lack of cooperation between farmers and conservationists in all study areas. Interviewees from all study areas were complaining that conservationists only care about their own requirements but do not consider the interests of farmers. There was no real cooperation between these two groups of interest, but mistrust of farmers towards conservationists in either observed study area (Table 16). The results from study areas in Germany reveal that linkage of livestock farming and wildlife management alone does not necessarily result in good relationships between farmers and conservationists. It seems as if insufficient consideration of the farmers' needs leads to negative attitudes towards conservation measures by farmers. Sustainable management strategies for biodiversity conservation require consideration of farming practices (e.g. Wells et al., 1992).

4.2.4 Major human-wildlife conflict associated with grazing of cattle

A further task was to identify the causes of major human-wildlife conflict (HWC) associated with cattle grazing in central Europe and sub-Saharan Africa.

4.2.4.1 Competition for rangelands

The results from the interview surveys reveal, that in contrast to the study areas in Germany, competition for pasture between cattle and wildlife is a serious issue in the African study areas (Table 19). Competition between livestock farming and wildlife in the African context has been described in several previous studies as well (e.g. Little, 1996; Galvin, 2009; Groom and Western, 2013; Fynn et al., 2016; Tyrrell et al., 2017). The more pronounced interactions and competition between livestock and wildlife in the African context can be explained by the fact that wildlife communities are less reduced (Bartlett et al., 2016) and livestock represents allochthon faunal elements compared to European landscapes (Van Vuure, 2002; Taberlet et al., 2008).

Moreover, several studies from sub-Saharan Africa describe a relation between aridity and competition over resources among livestock and wildlife, particularly pronounced during dry seasons and droughts (e.g. Dublin, 1995; Voeten and Prins, 1999; Prins, 2000; Ogutu and Owen-Smith, 2003; Ogutu et al., 2009; Odadi et al., 2011; Fynn et al., 2015). The climatic predictions for both geographical regions suggest increasing annual mean temperatures and more frequent extreme weather events in the current century (IPCC, 2013). Associated droughts can be assumed to raise tensions between livestock farming and wildlife (Prins, 2000); perhaps in the European context as well.

The highest level of HWC was identified in Serengeti Region (Figure 51). A high potential for diverse HWC at Serengeti National Park has been described previously, where diverse forms of land use (e.g. pastoralism, crop farming, wildlife conservation) compete for limited natural resources (e.g. Arcese et al., 1995; Sinclair et al., 2008; Olff and Hopcraft, 2008; Harris et al., 2009). Local communities in northern Tanzania face a lack of land rights (Makoye and Russel, 2016). The area used to be home and grazing land of local pastoral communities (Packer and Polasky, 2008), forced to leave when SNP was established (Olff and Hopcraft, 2008); respective resettlement of humans is a common practice in sub-Saharan Africa (e.g. Anderson and Cumming, 2013) and supposed to cause a negative attitude of affected people towards conservation measures (Homewood and Rodgers, 1984).

The more pronounced pressure identified in Serengeti Region, when compared to Etosha Region is probably also related to the different potential of protected land for farming. Germans introduced early conservation concepts in Etosha (Griffin, 1998) and Serengeti Region (Sinclair et al., 2008). However, in contrast to Serengeti, the focus of initial wildlife reserves in Namibia and Germany was not on conservation of biodiversity (Barnard, 1998; Sinclair et al., 2008; EEA, 2012). In Etosha Region wildlife was protected to ensure

human food security (Göttert and Zeller, 2008). Owing to the different conservation goals during the establishment of the two African protected areas, SNP is located on more fertile land compared to its surroundings (Olff and Hopcraft, 2008), while Etosha is located on land, unsuitable for farming (Barnard, 1998).

Additionally, there is a lack of land use planning in Serengeti Region (Notenbaert et al., 2012). 70% of the interviewees from Serengeti Region mentioned a lack of land use plans or participatory land use planning. The future of wildlife conservation in Africa depends on careful land use planning outside of protected areas (Nelson, 2008), while the needs of different land use forms should be considered during planning processes (Notenbaert et al., 2012).

Although SNP is not fenced, land use contrasts and edge effects were particularly pronounced in the associated study area. This was also identified during the camera-trap survey (chapter 4.1.1). Sinclair et al. (2008) explain this situation with lacking buffer zones and excessive livestock farming along the western border of the protected area. Two privately managed game reserves (Grumeti and Ikorongo) are functioning as buffer in parts of western SNP (Walpole et al., 2004). Apart from wildlife conservation and eco-tourism, human activities are prohibited in SNP (Thirgood et al., 2004; Olff and Hopcraft, 2008). Nevertheless, livestock farmers commonly graze cattle inside the protected areas including SNP (Table 16; Sinclair et al., 2008; Ogutu et al., 2009). Land use plans and buffer zones might have potential to reduce the HWC in the Serengeti Region (Olff and Hopcraft, 2008). However, buffer zones might reduce land use contrasts and associated HWC but rarely deliver social benefits for local people (Wells et al., 1992).

4.2.4.2 Intensity of conservation related to level of human-wildlife conflict

Both protected areas, associated with study areas in Germany are part of the European network Natura 2000 and comprise grazing of cattle as an important management tool. Despite their close proximity to each other and similar ecological conditions, there is an obvious difference between the two study areas in Germany. Compared to Lower Oder Valley (and other study areas), lowest level of human-wildlife conflict associated with livestock farming was identified in Havelland (Figure 51). No land use contrasts and edge effects were found in Havelland. However, despite low land use contrasts, pronounced edge effects were identified in Lower Oder Valley. The Situation in LOV can be considered special for several reasons: Privately conservationists make business with livestock farming ("naturalistic grazing" with focus on Heck cattle) in Lower Oder Valley (Schalitz, 2011; Vössing, 2012; Vössing, 2015). This, on the one hand causes land conflict with resident farmers (Vössing and Berg, 2005) and on the other hand does not match with the governments conservation goals and thus, hold-up the implementation of the national park (Vössing, 2011; Dietrich, 2012). Schmutz and Vössing (2009) excuse the pronounced edge effects along the boundary with the relatively thin shape and small dimensions of Lower Oder Valley National Park (Figure 8).

However, different protected area categories should also be considered. In contrast to Lower Oder Valley (and other study areas), Havelland holds a lower protection status (nature park instead of national park). The concept of nature park focuses on the conservation of cultural landscapes by sustainable use of resources, eco-tourism, preservation of traditions, involvement of local people and enhancement of awareness for conservation (Buchta, 2003). Diverse forms of land use, including livestock grazing are legitimate in nature parks (Kaden and Itzerott, 2003). Consequently, restrictions for farmers are relatively small. In contrast, Lower Oder Valley National Park was implemented in a cultural landscape without considering the interests of resident people. The case of Lower Oder Valley reveals, that a combination of nature conservation and livestock farming can cause conflicts as well.

Coexistence between livestock farming and nature conservation appears to be better in Havelland compared to Lower Oder Valley. Given similar ecological conditions and wildlife presence (SR and RCF) in both study areas (see results of camera trap surveys, Table 13) it can be questioned if the strict conservation status as a national park and associated conflicts in Lower Oder Valley are justified. Since protected areas with lower conservation level (less strict regulations) seem to have less conflict potential, they can be assumed to enable better coexistence between different land use forms.

The case of Etosha Region shows that private wildlife foundations benefit from HWC. Farmers reported several times that NGOs make money with large carnivores and actively boost conflicts to increase their fundraising (Figure 35). When looking at the study areas associated with Germany, there is a comprehensive network of privately organised conservation in Lover Oder Valley (Berg et al., 2001; Figure 29) only. This site specific difference probably also has impact on the different levels of HWC. Negative attitudes of farmers towards conservationists were more common in study areas with privately organised conservationists operating (all other study areas, except Havelland) (Table 16). Those foundations pursue economical interests (e.g. generate income through tourism, livestock products, lease of land, subsidies and fundraising). However, effective management strategies for biodiversity conservation are ought to balance between interests of farmers and conservation goals (Wells et al., 1992; ELO, 2010; DeFries et al., 2007). Good cooperation between farmers and conservationists can be assumed to be important for the sustainability of cattle farming and biodiversity conservation.

4.2.4.3 Conflict with livestock farming through strictly protected wildlife species

In all study areas, strictly protected wildlife species cause major human-wildlife conflict (HWC) with livestock farming. On the one hand the results show that HWC through large carnivores is perceived as high by farmers from all study areas, while HWC through large ungulates on the other hand is region specific. Farmers in study areas associated with sub-Saharan Africa perceive the conflict with naturally occurring ungulates higher than the interviewed farmers from central Europe (Figure 51). The identified protected conflict

species are the grey wolf (*Canis lupus*) in study areas associated with central Europe, and the African elephant (*Loxodonta africana*) in study areas associated with sub-Saharan Africa. Likewise, these species underlie strict conservation policies and at the same time have no natural enemy (e.g. Okarma and Langwald, 2002; Sinclair et al., 2008). The resulting rapid and uncontrolled population growth of the conflict species causes concern by interviewees in all study areas. Furthermore, problem animals are not eliminated consequently in both geographical regions (although policies include legal exceptions), which causes negative attitudes of farmers towards conservation. The conflict is new and increasing in both geographical regions, while effective management strategies are missing. Thus, it appears as if livestock farming and specific wildlife species are incompatible. Coexistence with livestock farming is difficult when wildlife is protected (Prins, 2000).

Livestock predation (mostly through *Crocuta crocuta*) is common at the observed African national parks and causes high socio-economic losses to livelihoods (Lindsey et al., 2013; Mwakatobe et al., 2013). SNP for instance comprises the highest abundance of large predators (e.g. *Panthera leo, Panthera Pardus, Acinonyx jubatus, Lycaon pictus and Crocuta crocuta*) on the globe (Sinclair et al., 2008). Although, considerablely more larger carnivore species occur in the African study areas (Appendix 7.1.1), human-wildlife conflict is obviously related to predation of livestock in Germany (Figure 51). There is a common concern about the increasing wolf population (*Canis lupus*) and a lack of effective strategies to mitigate related conflicts in both associated study areas. Wolves have caused predation of cattle in Havelland more recently (LfU, 2017), and have been proven to occur in LOV (Haverland 2011). The cause of the recent conflict can be explained as follows: Large canids like the wolf have been historically persecuted because of various HWC (depredation of livestock and humans, competition with hunters for prey, transmission of diseases) (Sillero-Zubiri et al., 2004). Nevertheless, the wolf is listed as endangered in Germany (BfN, 2009) and strictly protected through EU policies nowadays (EG, 1992). The wolf population is growing rapidly (MLUL, 2018a) and related predation of livestock (including cattle) is increasing respectively (MLUL, 2018b). A correlation between the increase in wolf population and risk of livestock predation has also been observed in the USA (Kompaniyets and Evans, 2017).

The wolf (*Canis lupus*) can easily cope with fragmented European landscapes (e.g. Okarma and Langwald, 2002; EC, 2014), where wolf presence is linked to livestock abundance (availability of prey) (Eggermann, 2009). In regions on the Iberian Peninsula for instance, wolves sustain mainly on livestock, making up more than 80% of the diet. Thus, wolves causes serious HWC and threat of biodiversity in cultural landscapes: Livestock predation by wolves results in the abandoning of livestock grazing (traditional land use) in European landscapes (EC, 2014), although an important tool in nature conservation (chapter 1.1). The "rewilding" movement in Europe not only benefits from intensification of agriculture and factory farming (Helmer et al., 2015), it can even support

the loss of traditional land use practices and associated agro-biodiversity (e.g. Nehls, 2018). The wolf (*Canis lupus*) is one of the most widespread mammals on earth (MLUL, 2018a) and according to IUCN Red List, belongs to the species with least concern (IUCN, 2019). Additionally breeding between wolves (*Canis lupus*) and domestic dogs (*Canis lupus* f. familiaris) is a common issue in European cultural landscapes, which endangers the stem species (Pilot et al., 2018). Given the diverse mentioned reasons the necessity of the strict protection status of *Canis lupus* should be reconsidered. HWC due to crop raiding elephants adjacent to the Serengeti National Park has been mentioned in several other studies (e.g. Walpole et al., 2004; Sinclair et al., 2008; Mwakatobe et al., 2014). The elephant population is growing rapidly due to strict conservation (Sinclair et al., 2008). Although conservationists propose a variety of practices, farmers cannot effectively mitigate conflicts with elephants (Walpole et al., 2004). Government officials are allowed to shoot an elephant when it has killed a human (Walpole et al., 2004). There is similar conflict in Etosha Region (Table 16) - commercial cattle farming and elephants appear incompatible. Infrastructure damage through elephants on commercial farms adjacent to Etosha National Park has been mentioned by Berry (1997) as well. A conservationist (interviewee HVL-10), responsible for wolf management in study areas associated with Germany said that coexistence with wolves needs to be enabled through money in Germany to justify an interference in African wildlife conservation. However, we have to be aware that coexistence between livestock farming and large carnivores in less disturbed African ecosystems is maintained through lethal control. In addition, elephants used to be managed in conservancies on commercial farmland in Namibia, where farmers regret that the conservancy system is not acknowledged anymore on the commercial land in Etosha Region. Interviewees from both geographical regions have reported that wildlife species show reduced fear of humans when not hunted. This is also mentioned by Walpole et al. (2004) for the case of elephants. It can be questioned if European interference in conservation management on the African continent is really sustainable. The European approach of strict species protection without having effective strategies in place causes HWC in fragmented European landscapes (large carnivores) and in less disturbed savannas of sub-Saharan Africa (elephants).

4.2.5 African management promise potential to mitigate livestock predation in Europe

Given the global conflict between humans and large carnivores (e.g. Sillero-Zubiri et al., 2004; Zimmermann, 2010) and a lack of effective management strategies to deal with currently increasing carnivore-livestock conflicts in fragmented European landscapes (e.g. EC, 2014; Fechter and Storch, 2014), the question here was, which management practices, inspired by practices of African farmers have potential to mitigate predation of cattle by large carnivores in central Europe. Although this concept has never existed in Europe, conservationists are looking for management strategies, which enable coexistence between livestock grazing and large carnivores (EC, 2014; Trouwborst, 2010; Fechter and Storch, 2014).

The results indicate a major region specific difference concerning strategies for lessening livestock predation by large carnivores. While farmers in HVL and LOV are lacking effective strategies to mitigate predation of cattle by carnivores, diverse practices are combined by African farmers. Next to preventive measures, there is no compensation for livestock losses, but lethal control of large carnivores in the African context. The EU policies allow the killing of large carnivores in exceptional cases only (Trouwborst, 2010). Strategies to mitigate livestock predation in study areas associated with Germany focus only on herd protection and awareness creation. Resistance against lethal control is typical for wealthy countries (Sillero-Zubiri et al., 2004). While preventive measures seem to overweigh lethal control measures in Serengeti Region, lethal control of carnivores is the basic strategy to reduce livestock predation in Etosha Region. However, it has to be considered that farmers in Namibia are allowed to kill large carnivores (Rust and Marker, 2014), while large carnivores are illegally killed by pastoralists in Tanzania (Ikanda and Packer, 2008). Poaching of wildlife is widespread in Serengeti Region (e.g. Loibooki et al., 2002; Kaltenborn et al., 2005; Olff and Hopcraft, 2008). Since illegal, farmers from Serengeti Region seemed to avoid to talk about hunting, but respective activities were mentioned by interviewees engaged in wildlife management. Additionally larger carnivores are hunted for trophies (hunting tourism) in Tanzania (Packer et al., 2011).

Hunting of large carnivores is an effective strategy to reduce associated HWC and has potential to improve the acceptance of conservation in public (Treves, 2009). The incorporation of lethal control (regulation of wolf population) can be assumed to effectively mitigate predation of livestock by wolves in the European context. Boitani and Moehrenschlager (2004) also propose to combine the control of carnivore populations, preventive measures (livestock management) and mitigation (compensation schemes). For instance in the USA, a hunting season helps to reduce predation on cattle by the otherwise protected wolf (Kompaniyets and Evans, 2017). Although integration of hunting is essential for management, while this should be restricted to allow populations to sustain (Okarma and Langwald, 2002). Lethal control of carnivores because of livestock predation can also have negative impact on the population, as it is the case for the lion in the Etosha Region (Trinkel et al., 2017). Canids reveal a high reproduction ability, which allows fast recovery of populations (Harris and Saunders, 1993; Kompaniyets and Evans, 2017). Population control measures should focus on individuals that are responsible for livestock predation but the experience from the USA shows, that it is necessary to reduce the wolf population by more than 25% to reach a decline in livestock predation (Kompaniyets and Evans, 2017).

In contrast to study areas associated with Africa, the management of large carnivores in Germany is base on compensation and support of a few preventive measures (electric fencing and guarding dogs). However, all interviewed German farmers, which have had cattle losses through wolves and consequently applied for compensation, were extremely disappointed with the compensation system. Compensation schemes are argued to be

ineffective for the mitigation of livestock predation, as they do not affect the causes of the conflict (Sillero-Zubiri et al., 2004).

Farmers in all study areas have management practices to prevent predation of cattle by large carnivores. However, protection of livestock in the African context focuses more on night hours (Table 17). For instance all interviewed farmers from Serengeti Region graze exclusively during daylight and use livestock enclosures (so-called bomas) and guarding dogs to protect the livestock during night.

Contrary to the other study areas, grazing of livestock (cattle, sheep and goat) is limited to daylight in Serengeti Region. This is typically for pastoral systems, where livestock is kept in bush-fenced enclosures so called "bomas" during night (Augustine, 2004; Augustine et al., 2011).

These are common traditional strategies to reduce livestock predation (Ukio, 2010; Augustine et al., 2011; Schuette et al., 2016). While conventional bomas are round enclosures made from thorny, woody vegetation (e.g. Augustine et al., 2011; Mwakatobe et al., 2013), recent ones, made of metal or canvas are more effective (Frank, 2011; Porensky and Veblen, 2015). It is known that preventive measures of traditional grazing practice have potential to reduce livestock predation by wolves (Sillero-Zubiri et al., 2004; EC, 2014). However, we have to be aware that cattle grazing in the European context can only be economical due to subsidies (EC, 2014). Thus, the extra effort spent by farmers must be compensated somehow so that livestock grazing remains profitable.

Intense electric fencing is promoted and subsidized as main strategy to reduce predation of cattle through larger carnivores in Germany. However, this is reported several times by respective farmers to be unsuitable for rotational grazing of cattle. Fencing seems to be a simple way to mitigate HWC but also involves high economical and ecological losses (e.g. Durant et al., 2015; Durant, 2017). Electrified game fences require intense effort for maintenance (Karhu and Anderson, 2006). The results from Etosha Region also reveal that the construction and maintenance of electric fences, with potential to hold back wildlife require lots of effort and thus is not practicable for cattle farming. Additionally, fences often have negative impact on wildlife as representing artificial barriers (Boone and Hobbs, 2004; Hobbs et al., 2008; Somers and Hayward, 2012; Durant, 2017). As fences are not selective, they have negative impact on other wildlife species like large herbivores as well (Boone and Hobbs, 2004). Electrified fences, used to mitigate conflicts with crop raiding elephants for instance restrict the movement of other wildlife species in Tanzania (Bonnington, 2009). Since elephants are able to learn, electric fences require additional shooting to effectively reduce associated conflict on farmland (Walpole et al., 2004). The camera trap survey from LOV also reveals that electrified fencing causes significant response in naturally occurring ungulates (roe deer). Species-specific response of wildlife

to livestock grazing should be considered when developing management strategies (Georgiadis et al., 2007).

Although, it is a common believe by interviewees in Germany that the risk of predation by wolves is lower in horned cattle compared to cattle without horns, this could not be confirmed for large carnivores in study areas associated with sub-Saharan Africa. However, local cattle breeds are supposed to reduce predation risk by wolves (EC, 2014), which would be a further reason for their preservation. Local breeds are usually associated with traditional land use (grazing), which is increasingly given up by farmers due to intensification of farming (EEA, 2012; FAO, 2016) but also recolonisation of large carnivores (EC, 2014).

A lack of practical knowledge about farming by conservationists was commonly mentioned in three out of four study areas. By this means preventive measures, proposed by conservationists were described to be neither practicable nor effective. Human-wildlife conflict can be increased due to ignorance of wildlife managers (Mwathe, 2007; Schumann et al., 2012).

The most promising preventive strategy identified during the interview surveys is to focus on the protection of calves. This was mentioned by interviewees from all study areas and is also described in literature about livestock-carnivore conflict (e.g. Hoogesteijn, 2001; EC, 2014). The application of game-proof fences should be limited to certain pastures for calving and young calves. As the results from the Etosha Region reveal, large-scale electric fencing is no solution for keeping predators out.

5 Conclusion

This thesis highlights the potential of comparative studies to improve the understanding of ecological relationships. Moreover, it confirms the importance of less disturbed African ecosystems for developing effective management strategies in favour of more transformed geographical regions (e.g. European landscapes). At the same time, the research design can support a more sustainable resource management in increasingly transformed African savannas by considering land use impact on European landscapes. Despite obvious differences in environmental conditions and grazing management between the observed study areas in central Europe and sub-Saharan Africa, the findings of the conducted interviews as well as the camera trap surveys reveal trans-regional similarities, which led to the following implications:

• The awareness for sustainable pasture management appears to be less pronounced in the African study areas, when compared to the European. This can be assumed to result from region specific policies. While sustainable farming is subsidised and economic losses by wildlife are compensated in Europe there is a lack of socio-economic benefits from conservation in the African context. However, the extra effort spent for conservation of biodiversity by farmers must be compensated somehow so that sustainable farming becomes profitable.

• In all study areas, lack of cooperation between farmers and conservationists was identified. There is a general desire for management strategies regarding conservation of biodiversity, which consider the requirements of farmers. Moreover, management practices need to be practicable for farmers, in order to be implemented. The fact, that all interviewees from Serengeti Region do either focus on cattle farming or wildlife conservation could be an indicator for the particularly unsustainable situation. Effective concepts for conservation of biodiversity should balance between interests of farmers and conservation goals. Since, improved cooperation between farmers and conservationists has potential for effective preservation of agro-biodiversity, following studies should focus on that aspect. Integration of livestock grazing into conservation concepts appear more beneficial than solely restrictions of farming by conservationists.

• Given the reduced wildlife community, livestock grazing is regularly used to maintain European open landscapes. The development of European grassland ecosystems emphasizes the importance of the native large herbivores for African savannas. The results from Africa reveal that cattle farming and wildlife management can be easier combined on commercial rangelands compared to communal rangelands, where livestock has high cultural value.

• The following factors turned out to support the sustainability of livestock grazing in Germany: 1. adaptation of livestock numbers to the available pasture, 2. livestock mobility, 3. additional feeding outside the growing season (during times of shortage). These practices can be assumed to improve the sustainability of livestock farming in the African context, due to prevention of overgrazing. However, management strategies should be flexible to address regional differences as well as changing ecological and socioeconomic conditions. Thus, careful consideration and adaptation is required when transferred to a different region in order to ensure sustainability.

• A common feature among all study areas is that strictly protected wildlife species, wolf (*Canis lupus*) in Germany and elephant (*Loxodonta africana*) in Africa are responsible for high HWC with livestock farmers. This indicates that coexistence between livestock farming and certain wildlife species is difficult, particularly when the conflicting wildlife species are strictly protected. The protection status of grey wolf and African elephant should be reconsidered since the European approach of strict species protection without having effective strategies in place causes HWC in fragmented European landscapes and in less disturbed savannas of sub-Saharan Africa. The control of respective wildlife populations appears promising.

• Farmers in Africa combine diverse practices including hunting of large carnivores to mitigate associated livestock predation. This suggests that integration of lethal control measures into wolf management can be effective to reduce related HWC in the European context. Additionally focussing on the protection of calves has potential to reduce cattle predation by large carnivores. The most promising preventive strategy identified, are particularly secured pastures for calving and young calves. The application of game-proof fences should be limited to these pastures. The results from Etosha Region reveal that large-scale electric fencing is incapable of excluding large carnivores from rangelands.

• Fencing requires lots of effort and at the same time causes negative impact on wildlife. Since fences are not selective, they represent artificial barriers for untargeted species as well. Given a relation between the number of wires and the level of wildlife disturbance, fencing in livestock farming should be limited as far as possible.

• Despite stable-appearing European agro-ecosystems, the impact of land use systems on wildlife species and communities should be reconsidered. Thus, land use management in the European context should be more orientated towards less disturbed African savannas with more intact wildlife communities (e.g. commercial farmland in Namibia). The results of these camera trap surveys indicate that a comparison limited to Europe with its reduced wildlife community can lead to misinterpretation of the impact of land use systems regarding their disturbance of wildlife. Consequently, further trans-regional research should be conducted, including other geographical regions. It would also be important to identify additional reference areas in sub-Saharan Africa.

• Given the highest potential species richness and livestock grazing without fences in Serengeti Region, this area was assumed to be a suitable reference site (less disturbed situation) in Africa. However, originally sustainable pastoral livestock grazing was not practiced in the observed area. Because of the particular fast human population growth and associated pressure on wildlife and habitats in Serengeti Region, more sustainable management practices are urgently needed to preserve the diverse wildlife community of the adjacent SNP. Ecosystems in Serengeti Region have more potential for conservation effort (e.g. "rewilding"), when compared to the fragmented European landscapes.

• Rotational grazing of livestock is traditionally common in Lower Oder Valley. Thus, the grazing system has contributed to the development of a cultural landscape, which is subject to strict conservation these days. It is not clear, for what reason "naturalistic grazing" is promoted by conservationists, when it does not reveal advantages for wildlife compared to the traditional rotational grazing system. The implementation of "naturalistic grazing" is rather associated with several regional land use conflicts. The traditional rotational livestock grazing is a very flexible land use system, which can be easily adapted to the requirements of conservation goals. Thus, rotational grazing appears to be better for wildlife compared to "naturalistic grazing".

• "Rewilding" in European fragmented ecosystems seems to cause enormous pressure on the current situation. A smooth implementation would require comprehensive change of current management practices and related resources. It appears to be more efficient to invest the effort in sub-Saharan Africa in order to preserve high quality reference sites. Owing to rapid human population growth, African wildlife communities are increasingly under pressure. Circumstances, which caused local extinction of wildlife in Europe, could be avoided in sub-Saharan Africa. Further studies should address the impact of "rewilding" on European agro-biodiversity (including open habitats, associated species and local livestock breeds).

• Differences between livestock forms and breeds regarding the adaptability to other ecological conditions should be more considered during the development of management strategies to mitigate conflicting livestock-wildlife interactions. The focus on livestock with pronounced anti predator behaviour can be an important factor in the adaptation of grazing systems to HWC with large carnivores. The preservation of traditional cattle breeds should not be neglected, as they similar to the African context will gain in importance for grazing systems in Europe, when interactions with wildlife increase (e.g. due to "rewilding" and climate change).

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7 Appendix

7.1 Camera trap surveys

7.1.1 Potentially occurring target species

Havelland and Lower Oder Valley:
Naturally occurring carnivores and ungulates with at least four kilogram body weight in the federal state of Brandenburg in Germany (Haferland, 2011; Teubner et al., 2015), information about their body weight (Klausnitzer et al., 2013) and if recorded during the camera trap surveys.

Table 20: Potentially occurring target species in Havelland and Lower Oder Valley

	Target species (13)	**Body weight (kg)**	**Recorded**	
			LOV	**HVL**
Carnivores (7)	**Family: Canidae**			
	Golden jackal (*Canis aureus*)	9		
	Raccoon dog (*Nyctereutes procyonoides*)	4 – 10	X	
	Red fox (*Vulpes vulpes*)	4.5 – 9	X	X
	Grey wolf (*Canis lupus*)	25 – 60		
	Family: Mustelidae			
	Eurasian otter (*Lutra lutra*)	6 - 13		
	Eurasian badger (*Meles meles*)	8.5 – 17.5	X	X
	Family: Procyonidae			
	Raccoon (*Procyon lotor*)	3 – 10	X	X
Ungulates (6)	**Family: Bovidae**			
	Mouflon (*Ovis orientalis*)	30 - 40 (45)		
	Family: Cervidae			
	European roe deer (*Capreolus capreolus*)	15 - 25	X	X
	Fallow deer (*Dama dama*)	30 – 65 (95)		
	Red deer (*Cervus elaphus*)	80 - 180		X
	Moose (*Alces alces*)	240–270 (600)		
	Family: Suidae			
	Wild boar (*Sus scrofa*)	50 - 200	X	X
	Further recorded mammalian wildlife			
	European hare (*Lepus europaeus*)			
	Martes spec.			

Etosha Region:

Naturally occurring carnivores and ungulates with at least four kilogram body weight in Etosha National Park (Bronner et al., 2003; Skinner and Chimimba, 2005), information about their body weight (Dorst and Dandelot, 1973) and if recorded during the survey.

Table 21: Potentially occurring target species in Etosha Region

	Target species (31)	**Body weight (kg)**	**Recorded**
Carnivores (12)	**Family: Canidae**		
	Cape fox (*Vulpes chama*)	3.5-4.5	X
	Black-backed jackal (*Canis mesomelas*)	9-14	X
	Family: Felidae		
	Caracal (*Felis caracal*)	16-18	X
	Cheetah (*Acinonyx jubatus*)	45-65	
	Leopard (*Panthera pardus*)	50-80	X
	Lion (*Panthera leo*)	120-205	
	Serval (*Felis serval*)	14-18	
	Wild cat (*Felis silvestris*)	up to 6.3	X
	Family: Hyaenidae		
	Aardwolf (*Proteles cristata*)	11-13.5	X
	Spotted hyaena (*Crocuta crocuta*)	45-80	X
	Striped hyaena (*Hyaena hyaena*)	54	
	Family: Mustelidae		
	Honey badger (*Mellivora capensis*)	11	X
Ungulates (19)	**Family: Bovidae**		
	Common eland (*Tragelaphus oryx*)	590-680	X
	Common wildebeest (*Connochaetus taurinus*)	160-270	
	Gemsbok (*Oryx gazella*)	205	X
	Greater Kudu (*Tragelaphus strepsiceros*)	255	X
	Grey Duiker (*Sylvicapra grimmia*)	10-14	X
	Hartebeest (*Alcelaphus buselaphus*)	125-200	X
	Impala (*Aepyceros melampus*)	45-80	
	Klipspringer (*Oreotragus oreotragus*)	13-18	X
	Kirk's dik-dik (*Madoqua kirkii*)	4.5-5.5	X
	Steenbok (*Raphicerus campestris*)	14	X
	Springbok (*Antidorcas marsupialis*)	*32-36*	X
	Family: Elephantidae		
	African elephant (*Loxodonta africana*)	3,500-6,500	X
	Family: Equidae		
	Mountain zebra (*Equus zebra*)	270	X
	Plains zebra (*Equus quagga*)	225-320	
	Family: Giraffidae		
	Giraffe (*Giraffa camelopardalis*)	1,200	X
	Family: Orycteropodiae		
	Aardvark (*Orycteropus afer*)	70	X
	Family: Rhinocerotidae		
	Black rhinoceros (*Diceros bicornis*)	1,000-1,500	
	White rhinoceros (*Ceratotherium simum*)	3,500-5,000	

Family: Suidae		
Common warthog (*Phacochoerus africanus*)	60-135	X

Further recorded mammalian wildlife

Cape / shrub hare (*Leupus capensis / L. saxatilis*)

Common Genet (*Genetta genetta*)

Chacma baboon (*Papio hamadryas*)

Serengeti Region:

Naturally occurring carnivores and ungulates with at least four kilogram body weight in Serengeti National Park of Tanzania (Serengeti Park, 2000), information about their body weight (Dorst and Dandelot, 1973) and if recorded during the camera trap survey.

Table 22: Potentially occurring target species in Serengeti Region

	Target species (41)	**Body weight (kg)**	**Recorded**
Carnivores (15)	**Family: Canidae**		
	African wild dog (*Lycaon pictus*)	25-32	
	Black-backed jackal (*Canis mesomelas*)	9-14	X
	Golden jackal (*Canis aureus*)	9	
	Side-striped jackal (*Canis adustus*)	9	X
	Family: Felidae		
	Caracal (*Felis caracal*)	16-18	X
	Cheetah (*Acinonyx jubatus*)	45-65	
	Leopard (*Panthera pardus*)	50-80	
	Lion (*Panthera leo*)	120-205	
	Serval (*Felis serval*)	14-18	
	Wild cat (*Felis silvestris*)	up to 6.3	X
	Family: Hyaenidae		
	Aardwolf (*Proteles cristata*)	11-13.5	
	Spotted hyaena (*Crocuta crocuta*)	45-80	X
	Striped hyaena (*Hyaena hyaena*)	54	X
	Family: Mustelidae		
	Honey badger (*Mellivora capensis*)	11	
	Family: Viverridae	11-13.5	
	African civet (*Civettictis civetta*)	9-20	X
Ungulates (26)	**Family: Bovidae**		
	African buffalo (*Syncerus caffer*)	320-820	
	Bohor reedbuck (*Redunca redunca*)	35-50	
	Bushbuck (*Tragelaphus scriptus*)	35-80	
	Common duiker (*Sylvicapra grimmia*)	10-14	
	Common eland (*Tragelaphus oryx*)	590-680	
	Common wildebeest (*Connochaetus taurinus*)	160-270	
	Grant´s gazelle (*Gazella granti*)	45-80	
	Hartebeest (*Alcelaphus buselaphus*)	125-200	
	Impala (*Aepyceros melampus*)	45-80	X

Kirk's dik-dik (*Madoqua kirkii*)	4.5-5-5	
Klipspringer (*Oreotragus oreotragus*)	13-18	
Lesser kudu (*Tragelaphus imberbis*)	55-105	
Mountain reedbuck (*Redunca fulvorufula*)	20-30	
Roan antelope (*Hippotragus equinus*)	225-275	
Steenbock (*Raphicerus campestris*)	14	
Thomson´s gazelle (*Gazella thomsonii*)	20-30	
Topi (*Damaliscus lunatus*)	135-160	
Waterbuck (*Kobus ellipsiprymnus*)	160-270	
Family: Elephantidae		
African elephant (*Loxodonta africana*)	3,500-6,500	
Family: Equidae		
Plains zebra (*Equus quagga*)	225-320	
Family: Giraffidae		
Giraffe (*Giraffa camelopardalis*)	1,200	
Family: Hippopotamidae		
Hippopotamus (*Hippopotamus amphibius*)	1,130-1,360 (2,600)	
Family: Orycteropodiae		
Aardvark (*Orycteropus afer*)	70	
Family: Rhinocerotidae		
Black rhinoceros (*Diceros bicornis*)	1,000-1,500	
Family: Suidae		
Bushpig (*Potamochoerus larvatus*)	55-80	X
Common warthog (*Phacochoerus africanus*)	60-135	

Further recorded mammalian wildlife

Banded mongoose (*Mungos mungo*)

Cape / shrub hare (*Leupus capensis / L. saxatilis*)

Chacma baboon (*Papio hamadryas*)

Common genet (*Genetta genetta*)

Common slender mongoose (*Galerella sanguinea*)

White-tailed mongoose (*Ichneumia albicauda*)

7.1.2 Data - Havelland

Table 23: Hardware parameter - camera trap survey Havelland

Camera number	Camera position		Observation							Grazing system
	Latitude	Longitude	Start	End	Malfunction	Trap days total	Trap days Cattle absent	Trap days Cattle present	Collected photos	
1	52.536360	12.568630	07.07.2017	10.09.2017	0	65	23	42	1,670	Rotational
2	52.536820	12.568810	07.07.2017	10.09.2017	0	65	23	42	1,955	Rotational
3	52.537220	12.569100	07.07.2017	10.09.2017	0	65	23	42	5,295	Rotational
4	52.537580	12.569900	07.07.2017	10.09.2017	0	65	23	42	15,050	Rotational
5	52.537180	12.570550	07.07.2017	10.09.2017	0	65	23	42	11,975	Rotational
6	52.537010	12.571210	07.07.2017	10.09.2017	0	65	23	42	10,925	Rotational
7	52.537110	12.571870	07.07.2017	10.09.2017	0	65	23	42	5,155	Rotational
8	52.537290	12.572560	07.07.2017	10.09.2017	0	65	23	42	7,175	Rotational
9	52.537430	12.573350	07.07.2017	10.09.2017	6	59	23	36	9,235	Rotational
10	52.537580	12.574100	07.07.2017	10.09.2017	0	65	23	42	6,565	Rotational
11	52.537540	12.577160	07.07.2017	10.09.2017	0	65	54	11	5,735	Rotational
12	52.537810	12.577690	07.07.2017	10.09.2017	3	62	54	8	2,995	Rotational
13	52.538010	12.578230	07.07.2017	10.09.2017	0	65	54	11	3,015	Rotational
14	52.538280	12.578890	07.07.2017	10.09.2017	0	65	54	11	2,050	Rotational
15	52.538540	12.579490	07.07.2017	10.09.2017	0	65	54	11	3,295	Rotational
16	52.538330	12.580140	07.07.2017	10.09.2017	0	65	54	11	2,915	Rotational
17	52.538130	12.580750	07.07.2017	10.09.2017	0	65	54	11	3,270	Rotational
18	52.537910	12.581300	07.07.2017	10.09.2017	0	65	54	11	3,650	Rotational
19	52.537680	12.581930	07.07.2017	10.09.2017	0	65	54	11	2,895	Rotational
20	52.537120	12.576960	07.07.2017	10.09.2017	0	65	54	11	2,645	Rotational
				Total	**9**	**1,291**	**770**	**521**	**107,465**	

Table 24: Absolute number of events - camera trap survey Havelland

Camera number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**	**C. absent** (710 days)	**C. present** (581) days)
Red deer (*Cervus elaphus*)	0	0	0	0	0	0	0	0	0	0	3	3	4	2	6	5	5	5	0	0	33	33	0
Roe deer (*Capreolus capreolus*)	3	2	2	16	10	2	2	0	1	11	34	22	34	21	80	59	66	55	30	28	478	436	42
Wild boar (*Sus scrofa*)	0	0	0	0	0	0	0	0	0	0	5	9	5	7	5	2	1	2	0	1	37	37	0
European badger (*Meles meles*)	4	4	2	5	4	3	2	0	1	0	0	0	0	1	1	0	0	0	0	0	27	8	19
Raccoon (*Procyon lotor*)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Red fox (*Vulpes vulpes*)	22	8	12	12	12	10	14	7	12	18	14	8	8	8	4	8	5	12	0	10	204	90	110
Wildlife total	29	14	16	33	26	15	18	7	14	30	56	42	51	39	96	74	77	74	30	40	**780**	**605**	**106**
Cattle (*Bos primigenius* f. taurus)	43	49	169	283	379	192	124	223	189	211	146	58	83	43	59	62	70	71	69	53	**2,576**	**4**	**2,572**
Human (*Homo sapiens*)	6	9	12	5	61	156	154	182	138	291	3	6	5	10	10	8	10	10	10	4	**1,090**	**55**	**971**
Further recorded fauna																							
Birds	0	1	2	2	1	0	1	0	0	0	0	1	3	0	1	0	1	3	0	0	16	9	7
European hare (*Lepus europaeus*)	65	42	45	66	138	114	61	33	30	42	7	14	18	22	18	21	20	26	1	5	785	395	390
Martes spec.	0	0	2	0	0	1	0	0	0	0	0	0	0	0	3	3	0	0	0	0	9	6	3

Table 25: Events per 100 trap days (RCF) - camera trap survey Havelland

Camera number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Median Cam. 1-20** (IQR) **Total**	**C. absent**	**C. present**
European badger	6.2	6.2	3.1	7.7	6.2	4.6	3.1	0.0	1.7	0.0	0.0	0.0	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0	**0.8** (3.5)	**0.0** (2.5)	**0.0** (3.3)
Raccoon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	**0.0** (0.0)	**0.0** (0.0)	**0.0** (0.0)
Red fox	33.8	12.3	18.5	18.5	18.5	15.4	21.5	10.8	20.3	27.7	21.5	12.9	12.3	12.3	6.2	12.3	7.7	18.5	0.0	15.4	**15.4** (6.6)	**13.0** (6.1)	**17.4** (22.6)
Red deer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	4.8	6.2	3.1	9.2	7.7	7.7	7.7	0.0	0.0	**0.0** (5.2)	**0.0** (6.0)	**0.0** (0.0)
Roe deer	4.6	3.1	3.1	24.6	15.4	3.1	3.1	0.0	1.7	16.9	52.3	35.5	52.3	32.3	123.1	90.8	101.5	84.6	46.2	43.1	**28.5** (49.2)	**35.0** (48.4)	**3.6** (14.9)
Wild boar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	14.5	7.7	10.8	7.7	3.1	1.5	3.1	0.0	1.5	**0.0** (4.2)	**0.0** (5.1)	**0.0** (0.0)
Wildlife total	44.6	21.6	24.7	50.8	40.1	23.1	27.7	10.8	23.7	44.6	86.2	67.7	78.5	60.0	147.7	113.9	118.4	113.9	46.2	61.5	**48.5** (53.5)	**55.1** (49.5)	**27.9** (25.7)
Cattle	66.2	75.4	260.0	435.4	583.1	295.4	190.8	343.1	320.3	332.3	224.6	93.5	127.7	66.2	90.8	95.4	107.7	109.2	106.2	81.5	**118.5** (208.8)	**0.0** (0.0)	**513.7** (379.0)
Human	9.2	13.8	18.5	7.7	93.8	240.0	236.9	280.0	233.9	447.7	4.6	9.7	7.7	15.4	15.4	12.3	15.4	15.4	15.4	6.2	**15.4** (119.3)	**4.0** (7.9)	**45.5** (175.4)
Further recorded fauna																							
Birds	0.0	1.5	3.1	3.1	1.5	0.0	1.5	0.0	0.0	0.0	0.0	1.6	4.6	0.0	1.5	0.0	1.5	4.6	0.0	0.0	**0.8** (1.6)	**0.0** (1.9)	**0.0** (0.6)
European hare	100.0	64.6	69.2	101.5	212.3	175.4	93.8	50.8	50.8	60.0	10.8	22.6	27.7	33.8	27.7	32.3	30.8	40.0	1.5	7.7	**45.4** (47.7)	**38** (53.9)	**29.9** (80.7)
Martes spec.	0.0	0.0	3.1	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	4.6	0.0	0.0	0.0	0.0	**0.0** (0.0)	**0.0** (0.0)	**0.0** (0.0)

7.1.3 Data - Lower Oder Valley

Table 26: Hardware parameter - camera trap survey Lower Oder Valley

Camera number	Camera position		Observation					Grazing system	
	Latitude	Longitude	Start	End	Malfunction	Trap days	Collected photos	Pasture	Fence
1	52.92470	14.14031	16.02.2017	24.04.2017	0	67	735	Rotation	None
2	52.92363	14.14068	16.02.2017	24.04.2017	0	67	550	Rotation	None
3	52.92255	14.14104	16.02.2017	24.04.2017	0	67	255	Rotation	None
4	52.92147	14.1414	16.02.2017	24.04.2017	0	67	290	Rotation	None
5	52.92037	14.14177	16.02.2017	24.04.2017	0	67	205	Rotation	None
6	52.92037	14.14177	16.02.2017	24.04.2017	0	67	350	Permanent	Electrified
7	52.91932	14.14213	16.02.2017	24.04.2017	0	67	1,060	Permanent	Electrified
8	52.91824	14.14249	16.02.2017	24.04.2017	0	67	830	Permanent	Electrified
9	52.91717	14.14286	16.02.2017	24.04.2017	0	67	415	Permanent	Electrified
10	52.91609	14.14322	16.02.2017	24.04.2017	0	67	500	Permanent	Electrified
11	52.91501	14.14358	16.02.2017	24.04.2017	0	67	880	Permanent	Electrified
12	52.91394	14.14395	16.02.2017	24.04.2017	0	67	1,085	Permanent	Electrified
13	52.91286	14.14431	16.02.2017	24.04.2017	0	67	1,095	Permanent	Electrified
14	52.91179	14.14467	16.02.2017	24.04.2017	0	67	545	Permanent	Electrified
15	52.91071	14.14504	16.02.2017	24.04.2017	0	67	1,235	Permanent	Electrified
16	52.91071	14.14504	16.02.2017	24.04.2017	0	67	450	Rotation	None
17	52.90963	14.1454	16.02.2017	24.04.2017	0	67	370	Rotation	None
18	52.90855	14.14576	16.02.2017	24.04.2017	0	67	1,060	Rotation	None
19	52.90748	14.14613	16.02.2017	24.04.2017	0	67	270	Rotation	None
20	52.9064	14.14649	16.02.2017	24.04.2017	0	67	705	Rotation	None
				Total	**0**	**1,340**	**12,885**		

Table 27: Absolute number of events - camera trap survey Lower Oder Valley

Camera number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total Cam. 1-20**	**Rotation pasture Cam. 1-5; 16-20**	**Permanent pastures Cam. 6-15**
European badger (*Meles meles*)	2	1	1	3	0	4	0	0	0	1	1	5	0	0	0	0	0	5	1	19	43	32	11
Raccoon (*Procyon lotor*)	1	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	3	1	0	9	8	1
Raccoon dog (*Nyctereutes procyonoides*)	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	6	1	0	14	13	1
Red fox (*Vulpes vulpes*)	5	6	0	2	9	10	2	0	0	6	6	0	3	0	1	1	0	40	6	23	120	92	28
Roe deer (*Capreolus capreolus*)	63	40	19	14	0	2	10	18	5	9	7	1	1	0	1	2	45	47	24	47	355	301	54
Wild boar (*Sus scrofa*)	1	2	4	0	1	1	4	1	1	0	3	1	1	0	2	2	5	1	2	2	34	20	14
Wildlife total	72	54	25	21	10	18	16	20	6	16	17	7	5	0	4	6	50	102	35	91	**575**	**466**	**109**
Cattle (*Bos primigenius* f. taurus)	0	0	0	0	0	5	28	34	10	20	22	52	54	31	38	0	0	0	0	0	294	0	294
Horse (*Equus ferus* f. caballus)	0	0	0	0	0	4	14	15	10	13	9	12	24	8	13	0	0	0	0	0	122	0	122
Livestock total	0	0	0	0	0	9	42	49	20	33	31	64	78	39	51	0	0	0	0	0	**416**	**0**	**416**
Human (*Homo sapiens*)	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	**10**	**10**	**0**
Further recorded fauna																							
Birds	4	1	6	11	3	0	0	1	3	2	0	0	1	1	0	1	1	6	1	0	42	34	8
Domestic dog (*Canis lupus f. familiaris*)	1	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0	7	5	2
Domestic cat (*Felis sylvestris f. catus*)	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	1	0	1	6	2	4
European hare (*Lepus europaeus*)	22	8	6	3	7	6	3	3	0	5	6	3	2	0	1	2	0	49	0	16	142	113	29
Martes spec.	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	2	8	6	2

Table 28: Events per 100 trap days (RCF) - camera trap survey Lower Oder Valley

Camera number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Median** (IQR) **Cam. 1-20**	**Median** (IQR) **Rotation pasture Cam. 1-5; 16-20**	**Median** (IQR) **Permanent pasture Cam. 6-15**	**Wilcoxon-test** **w-value**	**p-value**
European badger	3.0	1.5	1.5	4.5	0.0	6.0	0.0	0.0	0.0	1.5	1.5	7.5	0.0	0.0	0.0	0.0	0.0	7.5	1.5	28.4	**1.5** (3.4)	**1.5** (3.8)	**0.0** (1.5)	34.5	0.23
Raccoon	1.5	0.0	1.5	3.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	1.5	0.0	**0.0** (1.5)	**0.7** (1.5)	**0.0** (0.0)	29.0	>0.05
Raccoon dog	0.0	7.5	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	9.0	1.5	0.0	**0.0** (3.4)	**0.0** (1.5)	**0.0** (0.0)	34.0	0.12
Red fox	7.5	9.0	0.0	3.0	13.4	14.9	3.0	0.0	0.0	9.0	9.0	0.0	4.5	0.0	1.5	1.5	0.0	59.7	9.0	34.3	**3.7** (9.0)	**8.2** (10.5)	**2.2** (7.8)	34.0	0.23
Roe deer	94.0	59.7	28.4	20.9	0.0	3.0	14.9	26.9	7.5	13.4	10.4	1.5	1.5	0.0	1.5	3.0	67.2	70.1	35.8	70.1	**14.2** (39.2)	**47.8** (46.6)	**5.2** (11.2)	16.0	**>0.01**
Wild boar	1.5	3.0	6.0	0.0	1.5	1.5	6.0	1.5	1.5	0.0	4.5	1.5	1.5	0.0	3.0	3.0	7.5	1.5	3.0	3.0	**1.5** (1.5)	**3.0** (1.5)	**1.5** (1.1)	36.0	0.29
Wildlife total	107.5	80.6	37.3	31.3	14.9	26.9	23.9	29.9	9.0	23.9	25.4	10.4	7.5	0.0	6.0	9.0	74.6	152.2	52.2	135.8	**26.1** (59.3)	**63.4** (68.0)	**17.2** (17.2)	11.5	**<0.01**
Cattle	0.0	0.0	0.0	0.0	0.0	7.5	41.8	50.7	14.9	29.9	32.8	77.6	80.6	46.3	56.7	0.0	0.0	0.0	0.0	0.0	**3.7** (42.9)	**0.0** (0.0)	**44.0** (24.6)	100.0	**<0.01**
Horse	0.0	0.0	0.0	0.0	0.0	6.0	20.9	22.4	14.9	19.4	13.4	17.9	35.8	11.9	19.4	0.0	0.0	0.0	0.0	0.0	**3.0** (18.3)	**0.0** (0.0)	**18.7** (6.7)	100.0	**<0.01**
Livestock total	0.0	0.0	0.0	0.0	0.0	13.4	62.7	73.1	29.9	49.3	46.3	95.5	116.4	58.2	76.1	0.0	0.0	0.0	0.0	0.0	**6.7** (59.3)	**0.0** (0.0)	**60.4** (28.4)	100.0	**<0.01**
Human	3.0	3.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	4.5	**0.0** (0.4)	**0.7** (3.0)	**0.0** (0.0)	25.0	**>0.01**
Further recorded fauna																									
Birds	6.0	1.5	9.0	16.4	4.5	0.0	0.0	1.5	4.5	3.0	0.0	0.0	1.5	1.5	0.0	1.5	1.5	9.0	1.5	0.0	**1.5** (4.5)	**3.0** (6.8)	**0.8** (1.5)	22.0	0.03
European hare	32.8	11.9	9.0	4.5	10.4	9.0	4.5	4.5	0.0	7.5	9.0	4.5	3.0	0.0	1.5	3.0	0.0	73.1	0.0	24.9	**4.5** (6.7)	**9.7** (18.3)	**4.5** (4.9)	30.0	0.14
Domestic dog	1.5	0.0	0.0	0.0	3.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	**0.0** (0.4)	**0.0** (1.1)	**0.0** (0.0)	43.0	0.52
Domestic cat	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	**0.0** (0.0)	**0.0** (0.0)	**0.0** (0.0)	55.5	0.54
Martes spec.	0.0	0.0	3.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.0	**0.0** (0.0)	**0.0** (2.25)	**0.0** (0.0)	40.0	0.30

7.1.4 Data - Etosha Region

Table 29: Hardware parameter - camera trap survey Etosha Region

Camera number	Camera position		Observation					Farming system
	Latitude	Longitude	Start	End	Malfunction	Camera trap days	Collected photos	
1	-19.6802	14.8725	21.03.19	01.06.19	0	72	400	Cattle farm
2	-19.6822	14.8684	21.03.19	01.06.19	0	72	625	Cattle farm
3	-19.6846	14.8644	21.03.19	01.06.19	0	72	445	Cattle farm
4	-19.6883	14.8618	21.03.19	01.06.19	0	72	185	Cattle farm
5	-19.6928	14.8611	21.03.19	01.06.19	0	72	520	Cattle farm
6	-19.6102	14.9305	21.03.19	01.06.19	0	72	1,495	Cattle farm
7	-19.6110	14.9352	21.03.19	01.06.19	0	72	230	Cattle farm
8	-19.6116	14.9400	21.03.19	01.06.19	0	72	385	Cattle farm
9	-19.6120	14.9447	21.03.19	01.06.19	0	72	180	Cattle farm
10	-19.6126	14.9494	21.03.19	01.06.19	0	72	70	Cattle farm
11	-19.7827	14.9107	24.03.19	30.05.19	0	67	3,320	Wildlife farm
12	-19.7821	14.9073	15.03.19	30.05.19	0	76	1,075	Wildlife farm
13	-19.7813	14.9029	15.03.19	30.05.19	0	76	955	Wildlife farm
14	-19.7814	14.8977	15.03.19	30.05.19	0	76	1,075	Wildlife farm
15	-19.7815	14.8926	15.03.19	30.05.19	0	76	275	Wildlife farm
16	-19.7840	14.8885	15.03.19	30.05.19	14	62	105	Wildlife farm
17	-19.7873	14.8849	15.03.19	30.05.19	0	76	335	Wildlife farm
18	-19.7887	14.8800	15.03.19	30.05.19	0	76	960	Wildlife farm
19	-19.7889	14.8751	15.03.19	30.05.19	0	76	1,335	Wildlife farm
20	-19.7892	14.8702	24.03.19	30.05.19	17	50	6,720	Wildlife farm
				Total	**31**	**1,431**	**20,690**	
				Cattle farm	**0**	**720**	**4,535**	
				Wildlife farm	**31**	**711**	**16,155**	

Table 30: Absolute number of events - camera trap survey Etosha Region

Camera number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**	**Cattle farm** (720 days)	**Wildlife farm** (711 days)
Aardwolf (*Proteles cristata*)	1	2	0	0	0	0	1	2	0	0	0	1	0	1	0	1	3	2	4	0	**18**	6	12
Black-backed jackal (*Canis mesomelas*)	5	13	10	3	6	0	2	5	0	0	0	32	0	6	2	0	4	2	3	1	**94**	44	50
Cape fox (*Vulpes chama*)	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**3**	3	0
Caracal (*Felis caracal*)	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2	0	1	0	0	**5**	1	4
Honey badger (*Mellivora capensis*)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	**2**	1	1
Leopard (*Panthera pardus*)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**	0	1
Spotted hyaena (*Crocuta crocuta*)	0	0	0	0	0	0	0	0	0	0	15	0	1	1	1	0	4	2	2	6	**32**	0	32
Wild cat (*Felis silvestris*)	0	0	0	0	1	0	0	1	0	0	0	2	0	0	0	0	0	0	3	0	**7**	2	5
Aardvark (*Orycteropus afer*)	1	5	1	0	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**13**	13	0
African elephant (*Loxodonta africana*)	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	**5**	0	5
Common eland (*Tragelaphus oryx*)	0	2	0	0	0	0	0	0	0	0	103	4	1	2	0	0	1	6	9	8	**136**	2	134
Common warthog (*Phacochoerus africanus*)	2	0	3	0	2	0	0	1	0	0	0	4	0	1	1	2	0	0	0	3	**19**	8	11
Gemsbok (*Oryx gazella*)	8	6	15	6	20	42	20	13	17	8	63	35	49	59	5	7	9	40	40	27	**489**	155	334
Giraffe (*Giraffa camelopardalis*)	0	3	0	0	1	1	1	1	0	0	31	4	13	3	2	0	1	4	2	6	**73**	7	66
Greater Kudu (*Tragelaphus strepsiceros*)	7	9	2	1	3	3	0	1	0	1	123	30	23	17	10	0	0	12	26	9	**277**	27	250
Grey Duiker (*Sylvicapra grimmia*)	1	9	0	0	5	2	0	0	0	0	2	7	0	0	0	1	0	0	0	1	**28**	17	11
Hartebeest (*Alcelaphus buselaphus*)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	1	0
Klipspringer (*Oreotragus oreotragus*)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	**4**	0	4
Kirk's dik-dik (*Madoqua kirkii*)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	8	4	5	0	**18**	0	18
Mountain zebra (*Equus zebra*)	17	17	11	4	17	0	0	0	0	0	65	10	18	27	13	0	19	44	65	257	**584**	66	518
Springbok (*Antidorcas marsupialis*)	3	12	8	10	16	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**50**	49	1
Steenbok (*Raphicerus campestris*)	0	2	2	0	0	0	0	2	0	0	0	6	0	1	0	0	0	0	0	0	**13**	6	7
Wildlife total	46	80	53	25	71	53	25	28	17	10	407	137	105	118	34	14	49	117	160	323	**1,872**	**408**	**1,464**
Cattle (*Bos primigenius* f. taurus/indicus)	7	5	4	1	5	61	13	22	8	0	0	0	0	0	0	0	0	0	0	0	**126**	**126**	**0**
Human (*homo sapiens*)	1	1	0	0	0	1	0	0	1	0	17	0	0	3	0	0	0	0	14	4	**42**	**4**	**38**
Further recorded fauna																							
Birds	0	1	1	1	4	0	0	0	0	0	0	4	0	0	0	1	2	1	1	0	16	7	9
Cape / shrub hare (*Leupus capensis / L. saxatilis*)	0	4	4	0	0	0	0	2	0	0	1	3	0	0	0	0	1	0	8	0	23	10	13
Chacma baboon (*Papio hamadryas*)	1	2	1	0	7	0	0	1	0	0	9	11	2	5	4	0	0	4	7	20	74	12	62
Common Genet (*Genetta genetta*)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	1
Domestic dog (*Canis lupus* f. familiaris)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

Table 31: Events per 100 trap days (RCF) - camera trap survey Etosha Region

Camera number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Median 1-20** (IQR)	**Cattle farm 1-10** (IQR)	**Wildlife farm 11-20** (IQR)
Aardwolf	1.39	2.78	0.00	0.00	0.00	0.00	1.39	2.78	0.00	0.00	0.00	1.32	0.00	1.32	0.00	1.61	3.95	2.63	5.26	0.00	**0.66** (1.87)	**0.00** (1.39)	**1.32** (2.38)
Black-backed jackal	6.94	18.06	13.89	4.17	8.33	0.00	2.78	6.94	0.00	0.00	0.00	42.11	0.00	7.89	2.63	0.00	5.26	2.63	3.95	2.00	**3.36** (7.18)	**5.56** (7.29)	**2.63** (4.43)
Cape fox	1.39	0.00	1.39	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00** (0.00)	**0.00** (1.04)	**0.00** (0.00)
Caracal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	1.32	0.00	0.00	0.00	3.23	0.00	1.32	0.00	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.99)
Honey badger	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)
Leopard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.61	0.00	0.00	0.00	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)
Spotted hyaena	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.39	0.00	1.32	1.32	1.32	0.00	5.26	2.63	2.63	12.00	**0.00** (1.64)	**0.00** (0.00)	**1.97** (3.29)
Wild cat	0.00	0.00	0.00	0.00	1.39	0.00	0.00	1.39	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00	0.00	3.95	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)
Aardvark	1.39	6.94	1.39	0.00	0.00	6.94	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00** (0.35)	**0.69** (1.39)	**0.00** (0.00)
African elephant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)
Common eland	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	153.73	5.26	1.32	2.63	0.00	0.00	1.32	7.89	11.84	16.00	**0.00** (3.30)	**0.00** (0.00)	**3.95** (9.54)
Common warthog	2.78	0.00	4.17	0.00	2.78	0.00	0.00	1.39	0.00	0.00	0.00	5.26	0.00	1.32	1.32	3.23	0.00	0.00	0.00	6.00	**0.00** (2.78)	**0.00** (2.43)	**0.66** (2.75)
Gemsbok	11.11	8.33	20.83	8.33	27.78	58.33	27.78	18.06	23.61	11.11	94.03	46.05	64.47	77.63	6.58	11.29	11.84	52.63	52.63	54.00	**25.69** (41.73)	**19.44** (15.63)	**52.63** (41.46)
Giraffe	0.00	4.17	0.00	0.00	1.39	1.39	1.39	1.39	0.00	0.00	46.27	5.26	17.11	3.95	2.63	0.00	1.32	5.26	2.63	12.00	**1.39** (4.44)	**0.69** (1.39)	**4.61** (7.68)
Greater Kudu	9.72	12.50	2.78	1.39	4.17	4.17	0.00	1.39	0.00	1.39	183.58	39.47	30.26	22.37	13.16	0.00	0.00	15.79	34.21	18.00	**6.94** (17.70)	**2.08** (2.78)	**20.18** (19.41)
Grey Duiker	1.39	12.50	0.00	0.00	6.94	2.78	0.00	0.00	0.00	0.00	2.99	9.21	0.00	0.00	0.00	1.61	0.00	0.00	0.00	2.00	**0.00** (2.19)	**0.00** (2.43)	**0.00** (1.90)
Hartebeest	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)
Klipspringer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)
Kirk's dik-dik	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	0.00	0.00	0.00	10.53	5.26	6.58	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (4.28)
Mountain zebra	23.61	23.61	15.28	5.56	23.61	0.00	0.00	0.00	0.00	0.00	97.01	13.16	23.68	35.53	17.11	0.00	25.00	57.89	85.53	514.00	**20.36** (27.63)	**2.78** (21.53)	**30.26** (59.87)
Springbok	4.17	16.67	11.11	13.89	22.22	0.00	0.00	0.00	0.00	0.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00** (2.16)	**2.08** (13.19)	**0.00** (0.00)
Steenbok	0.00	2.78	2.78	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	7.89	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	**0.00** (0.33)	**0.00** (2.08)	**0.00** (0.00)
Wildlife total	63.89	111.11	73.61	34.72	98.61	73.61	34.72	38.89	23.61	13.89	607.46	180.26	138.16	155.26	44.74	22.58	64.47	153.95	210.53	646.00	**73.61** (116.43)	**51.39** (38.89)	**154.61** (120.07)
Cattle	9.72	6.94	5.56	1.39	6.94	84.72	18.06	30.56	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00** (7.64)	**0.00** (0.00)	**8.33** (10.42)
Human	1.39	1.39	0.00	0.00	0.00	1.39	0.00	0.00	1.39	0.00	25.37	0.00	0.00	3.95	0.00	0.00	0.00	0.00	18.42	8.00	**0.00** (1.39)	**0.00** (1.39)	**0.00** (6.99)
Further recorded fauna																							
Birds	0.00	1.39	1.39	1.39	5.56	0.00	0.00	0.00	0.00	0.00	0.00	5.26	0.00	0.00	0.00	1.61	2.63	1.32	1.32	0.00	**0.00** (1.39)	**0.00** (1.39)	**0.00** (1.54)
Cape / shrub hare	0.00	5.56	5.56	0.00	0.00	0.00	0.00	2.78	0.00	0.00	1.49	3.95	0.00	0.00	0.00	0.00	1.32	0.00	10.53	0.00	**0.00** (1.81)	**0.00** (1.45)	**0.00** (2.08)
Chacma baboon	1.39	2.78	1.39	0.00	9.72	0.00	0.00	1.39	0.00	0.00	13.43	14.47	2.63	6.58	5.26	0.00	0.00	5.26	9.21	40.00	**2.01** (7.24)	**0.69** (1.39)	**5.92** (9.09)
Common Genet	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)
Domestic dog	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00** (0.00)	**0.00** (0.00)	**0.00** (0.00)

7.1.5 Data - Serengeti Region

Table 32: Hardware parameter - camera trap survey Serengeti Region

Camera number	Camera position		Observation					Grazing system
	Latitude	Longitude	Start	End	Malfunction	Trap days	Collected photos	
1	-2.1288	33.8709	25.10.2017	15.11.2017	0	21	585	Agro-pastoralism
2	-2.1279	33.8709	25.10.2017	15.11.2017	0	21	600	Agro-pastoralism
3	-2.1270	33.8710	26.10.2017	15.11.2017	0	20	575	Agro-pastoralism
4	-2.1261	33.8710	26.10.2017	15.11.2017	0	20	760	Agro-pastoralism
5	-2.1252	33.8710	26.10.2017	15.11.2017	0	20	760	Agro-pastoralism
6	-2.1243	33.8711	26.10.2017	15.11.2017	0	20	1,865	Agro-pastoralism
7	-2.1234	33.8711	26.10.2017	15.11.2017	0	20	635	Agro-pastoralism
8	-2.1225	33.8711	26.10.2017	15.11.2017	0	20	665	Agro-pastoralism
9	-2.1216	33.8714	26.10.2017	15.11.2017	0	20	600	Agro-pastoralism
10	-2.1207	33.8714	26.10.2017	15.11.2017	0	20	890	Agro-pastoralism
11	-2.1189	33.8712	04.11.2017	15.11.2017	0	11	330	Agro-pastoralism
12	-2.1189	33.8712	04.11.2017	04.11.2017	0	0	0	Agro-pastoralism
13	-2.1180	33.8710	04.11.2017	15.11.2017	0	11	470	Agro-pastoralism
14	-2.1171	33.8709	04.11.2017	15.11.2017	0	11	480	Agro-pastoralism
15	-2.1162	33.8708	04.11.2017	04.11.2017	0	0	0	Agro-pastoralism
16	-2.1153	33.8706	04.11.2017	15.11.2017	0	11	455	Agro-pastoralism
17	-2.1144	33.8703	04.11.2017	15.11.2017	0	11	245	Agro-pastoralism
18	-2.1135	33.8700	04.11.2017	04.11.2017	0	0	0	Agro-pastoralism
19	-2.1127	33.8697	04.11.2017	15.11.2017	0	11	535	Agro-pastoralism
20	-2.1118	33.8694	04.11.2017	12.11.2017	0	8	520	Agro-pastoralism
				Total	**0**	**276**	**10,970**	

Table 33: Absolute number of events - camera trap survey Serengeti Region

Camera number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**
African civet (Civettictis civetta)	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	3
Black-backed jackal (Canis mesomelas)	2	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	6
Caracal (Felis caracal)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Side-striped jackal (Canis adustus)	1	2	0	0	0	1	0	0	11	0	0	0	0	0	0	0	0	0	0	0	15
Spotted hyaena (Crocuta crocuta)	1	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	5
Striped hyaena (Hyaena hyaena)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Wild cat (Felis silvestris)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bushpig (Potamochoerus larvatus)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Impala (Aepyceros melampus)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Wildlife total	5	3	3	1	0	1	0	0	19	0	1	0	0	0	0	0	0	0	0	0	33
Cattle (*Bos primigenius* f. taurus/indicus)	25	25	25	30	29	37	30	24	15	30	14	0	68	24	0	18	12	0	23	16	445
Goat (*Capra aegagrus* f. hircus)	8	5	11	6	8	11	5	10	7	7	2	0	35	4	0	9	8	0	3	2	141
Sheep (*Ovis ammon* f. aries)	12	7	5	2	5	9	2	2	5	3	9	0	6	4	0	2	3	0	0	1	77
Livestock total	45	37	41	38	42	57	37	36	27	40	25	0	109	32	0	29	23	0	26	19	663
Human	5	8	25	13	8	25	10	12	11	11	6	0	17	5	0	4	7	0	4	7	178
Further recorded fauna																					
Birds	3	0	1	3	0	5	0	1	2	6	8	0	7	2	0	5	2	0	1	0	46
Cape / shrub hare (*Leupus capensis / L. saxatilis*)	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Chacma baboon (*Papio hamadryas*)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Common genet (*Genetta genetta*)	0	0	1	1	3	1	1	5	2	1	1	0	0	0	0	1	1	0	0	0	18
Domestic dog (*Canis lupus* f. familiaris)	2	0	0	0	0	0	0	1	10	1	0	0	0	0	0	0	0	0	0	0	14
Mongooses	1	5	0	1	1	2	5	1	0	5	2	0	0	0	0	0	0	0	0	0	23

Table 34: Events per 100 trap days (RCF) - camera trap survey Serengeti Region

Camera number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Median (IQR)
African civet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	9.09		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Black-backed jackal	9.52	4.76	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Caracal	4.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Side-striped jackal	4.76	9.52	0.00	0.00	0.00	5.00	0.00	0.00	55.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Spotted hyaena	4.76	0.00	10.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Striped hyaena	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Wild cat	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Bushpig	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Impala	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Wildlife total	23.81	14.29	15.00	5.00	0.00	5.00	0.00	0.00	95.00	0.00	9.09		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (6.02)
Cattle	119.05	119.05	125.00	150.00	145.00	185.00	150.00	120.00	75.00	150.00	127.27		618.18	218.18		163.64	109.09		209.09	200.00	150 (65.00)
Goat	38.10	23.81	55.00	30.00	40.00	55.00	25.00	50.00	35.00	35.00	18.18		318.18	36.36		81.82	72.73		27.27	25.00	36.36 (27.73)
Sheep	57.14	33.33	25.00	10.00	25.00	45.00	10.00	10.00	25.00	15.00	81.82		54.55	36.36		18.18	27.27		0.00	12.50	25.00 (23.86)
Livestock total	214.29	176.19	205.00	190.00	210.00	285.00	185.00	180.00	135.00	200.00	227.27		990.91	290.91		263.64	209.09		236.36	237.50	210 (47.50)
Human	23.81	38.10	125.00	65.00	40.00	125.00	50.00	60.00	55.00	55.00	54.55		154.55	45.45		36.36	63.64		36.36	87.50	55.00 (25.00)
Further recorded fauna																					
Birds	14.29	0.00	5.00	15.00	0.00	25.00	0.00	5.00	10.00	30.00	72.73		63.64	18.18		45.45	18.18		9.09	0.00	14.29 (20.00)
Cape / shrub hare	0.00	9.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Chacma baboon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00		9.09	12.50	0.00 (0.00)
Common genet	0.00	0.00	5.00	5.00	15.00	5.00	5.00	25.00	10.00	5.00	9.09		0.00	0.00		9.09	9.09		0.00	0.00	5.00 (9.09)
Domestic dog	9.52	0.00	0.00	0.00	0.00	0.00	0.00	5.00	50.00	5.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00 (0.00)
Mongooses	4.76	23.81	0.00	5.00	5.00	10.00	25.00	5.00	0.00	25.00	18.18		0.00	0.00		0.00	0.00		0.00	0.00	4.76 (10.00)

7.2 Problem-centred interviews

7.2.1 Questionnaire

QUESTIONAIRE REGARDING BASIC PARAMETERS OF CATTLE FARMING

Thomas Rottstock ▪ Deutsch Bork 37 ▪ 14822 Linthe

HUMBOLDT-UNIVERSITÄT ZU BERLIN

Part of the dissertation

"A comparative approach to livestock-wildlife interactions in central Europe and sub-Saharan Africa"

A synthesis of four case studies

Dear Sir or Madam,

Thank you very much for participating in this survey, which is part of my dissertation. This comparative study aims to gain a better understanding of the interrelations between livestock and wildlife (naturally occurring carnivores and ungulates with at least four kilogram body weight) and therefore provide advice for more effective and sustainable grazing- and wildlife management in central Europe and sub-Saharan Africa. The following questionnaire functions as preparation for a later interview. All the obtained information will be handled anonymously.

Hints on how to fill out this questionnaire

Sometimes you have to tick the right answer: ☒ true ☐ false

Otherwise you write the answer into the provided field: _____

QUESTIONAIRE REGARDING BASIC PARAMETERS OF CATTLE FARMING

Code of cattle farmer:

How is your income composed?

___% of the income results from livestock farming

___% from _____

How much land do you farm on?

____ arable land; ____ grassland (from that _____ pasture)

How is the pasture structured?

Number of paddocks: ____

Average size of the pasture: ____

Maximum distance from the farm building: ____

Motives for cattle farming:	**trivial**	**middle**	**crucial**
Dairy production	☐	☐	☐
Meet production	☐	☐	☐
Use as labour force	☐	☐	☐
Source of manure	☐	☐	☐
Culture, tradition	☐	☐	☐
Landscaping	☐	☐	☐

Criteria for selection of cattle breeds:			
High performance	☐	☐	☐
Adaption to environmental conditions / robustness	☐	☐	☐
Preservation of traditional breeds	☐	☐	☐
Long horns	☐	☐	☐

How many cattle and which breeds do you keep?

Total number of cattle kept: _____

Kept cattle breeds: _____

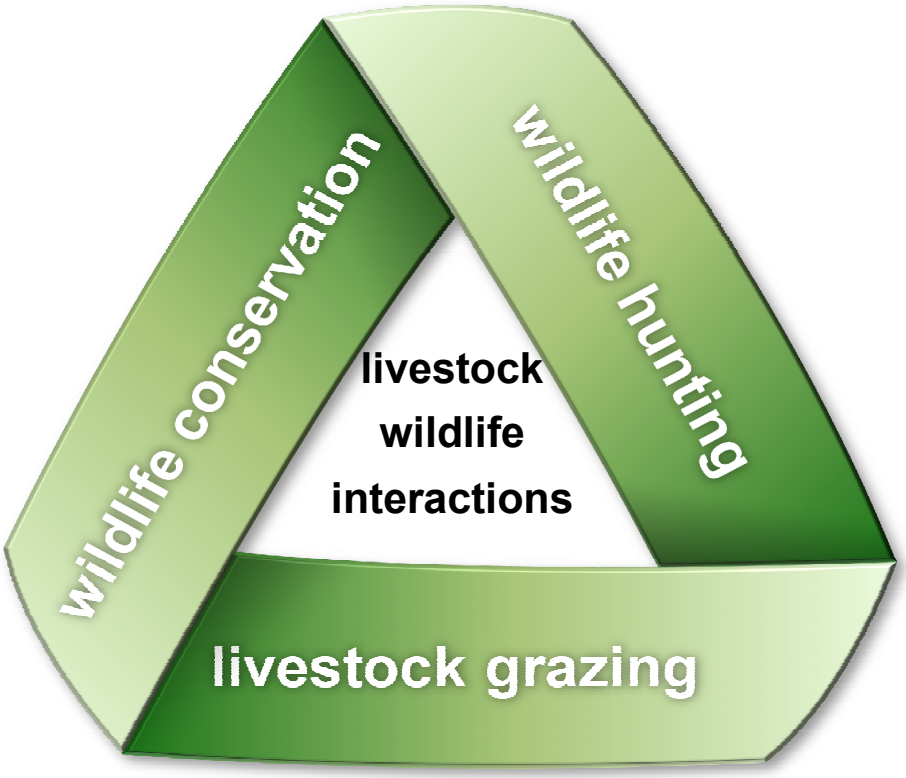
Which other animals do you graze besides cattle?

_____

7.2.2 Interview guide

Guide for the problem-centred interviews

Thank you very much that you have agreed to attend this survey, which is part of my dissertation at the Humboldt-Universität zu Berlin. The comparative studies focus on livestock grazing and associated interactions with wildlife in Germany, Namibia and Tanzania. Background of that survey is the influences of agro-biodiversity through land use changes, associated with the intensification of agriculture. During the interview, you are supposed to answer freely and comprehensively. I will hold back with questions as far as possible. With your permission, I will record our conversation. All information obtained will be handled anonymously.



This comparative study is supposed to identify region specific elements as well as common patterns of livestock-wildlife interactions in central Europe and sub-Saharan Africa. The overall objective is to gain a better understanding of the interrelations between livestock and larger naturally occurring mammals and therefore to enable advise for an effective and sustainable management practices.

INTERVIEW GUIDE

LIVESTOCK MANAGEMENT

What are the central elements of the applied grazing management?

- How is the grazing of cattle organised throughout the year?
- How do you perceive the ecological impact of cattle farming?
- What practices do you apply to maintain a good quality of the grazing land?
- How do you decide on the intensity of grazing?
- Is the livestock fed when there is shortage of pasture?

WILDLIFE MANAGEMENT

How is the regional wildlife management (conservation and hunting) organised?

- How is cattle farming restricted by nature conservation?
- What can be done to increase the sustainability of the wildlife management?

LIVESTOCK-WILDLIFE INTERACTIONS

Which regional HWC exist in association with the grazing of cattle?

- Which strategies do exist to solve these HWC?
- What are the reasons for conflicting livestock-wildlife interactions?
- How is compensation of damages through wildlife (carnivores and ungulates) regulated?
- Which strategies are applied to protect livestock from predation by larger carnivores?
- What could be done to improve the coexistence of livestock and wildlife?
- What influence does the grazing of cattle have on the presence and behaviour of wildlife?

7.2.3 Lists of respondents

Table 35: Interviewees and their positions in Lower Oder Valley (Germany)

Code	Position	Date
LOV-1	Local hunter, 16248 Lunow	27.03.2017
LOV-2	Cattle farm, 16303 Schwedt/Oder	30.03.2017
LOV-3	Cattle farm, 16248 Lunow-Stolzenhagen	30.03.2017
LOV-4	Private conservationist, 16303 Schwedt/Oder	04.04.2017
LOV-5	Local hunter, 16248 Lunow-Stolzenhagen	04.04.2017
LOV-6	Cattle farm, 16278 Angermünde	04.04.2017
LOV-7	Employee of a wildlife foundation, 16303 Schwedt/Oder	09.04.2017
LOV-8	Private conservationist, 16303 Schwedt/Oder	12.04.2017
LOV-9	Cattle farm, 16248 Lunow-Stolzenhagen	24.04.2017

Table 36: Interviewees and their positions in Havelland (Germany)

Code	Position	Date
HVL-1	Local hunter, 14778 Beetzseeheide	17.07.2017
HVL-2	Local hunter, 14778 Päwesin	18.07.2017
HVL-3	Cattle farm, 14778 Beetzseeheide	01.08.2017
HVL-4	Cattle farm, 14715 Märkisch Luch	01.08.2017
HVL-5	Cattle farm, 14715 Märkisch Luch	21.08.2017
HVL-6	Local hunter, 14778 Beetzseeheide	21.08.2017
HVL-7	Cattle farm, 14715 Nennhausen	27.09.2017
HVL-8	Westhavelland Nature Park, 14715 Havelaue	27.09.2017
HVL-9	Cattle farm, 14778 Päwesin	18.01.2019
HVL-10	Ministery for rural development, environment and agriculture of the state of Brandenburg, 14467 Potsdam	05.02.2019

Table 37: Interviewees and their positions in Serengeti Region (Tanzania)

Code	Position	Date
TZ-1	Local cattle farmer (Sukuma tribe) Bunda town	31.10.2017
TZ-2	Local cattle farmer (Sukuma tribe) Bunda town	31.10.2017
TZ-3	Local cattle farmer (Kuria tribe) Bunda town	07.11.2017
TZ-4	Local cattle farmer (Sukuma tribe) Bunda town	08.11.2017
TZ-5	District Game Officer	09.11.2017
TZ-6	Wildlife Manager of privately managed protected area	21.11.2017
TZ-7	District Game Officer	27.11.2017
TZ-8	Community Manager of privately managed protected area	04.12.2017
TZ-9	Executive Director of a pastoralists NGO	15.12.2017
TZ-10	HWC manager of a local NGO	19.12.2017

Table 38: Interviewees and their positions in Etosha Region (Namibia)

Code	Position	Date
NAM-1	Commercial cattle farmer near Outjo	01.04.2019
NAM-2	Manager of a wildlife farm near Kamanjab	16.04.2019
NAM-3	Owner of a wildlife farm near Outjo	18.04.2019
NAM-4	Manager of a mixed farm (wildlife and cattle) near Outjo	28.04.2019
NAM-5	Management of hunting farm south of Etosha National Park	30.04.2019
NAM-6	Commercial cattle farmer south of Etosha National Park	03.05.2019
NAM-7	Commercial cattle farmer south of Etosha National Park	14.05.2019
NAM-8	Commercial cattle farmer south of Etosha National Park	14.05.2019
NAM-9	Commercial cattle farmer south of Etosha National Park	15.05.2019
NAM-10	Commercial cattle farmer south of Etosha National Park	15.05.2019
NAM-11	Commercial cattle farmer south of Etosha National Park	16.05.2019
NAM-12	Commercial cattle farmer south of Etosha National Park	22.05.2019
NAM-13	Commercial cattle farmer south of Etosha National Park	22.05.2019
NAM-14	Owner of wildlife guest farm south of Etosha National Park	23.05.2019

7.2.4 Code lists

Havelland

Stakeholder functions and relations
• *"hunting is organized in a regional cooperation"*①
• *"we have a good relationship with the farmers"*①
• *"I do not know any conservationists in our region"*①
• *"we hunters are organized in a regional cooperation"*②
• *"20 % income from livestock farming"*③
• *"we have nothing to do with conservationists"*③
• *"we have a good relationship with the hunters… a fair cooperation"*③
• *"70 % income from livestock farming"*④
• *"we graze our cattle in a protected area"*④
• *"50 % income from livestock farming"*⑤
• *"we have nothing to do with conservationists"*⑤
• *"we plan the annual hunting commonly"*⑥
• *"we do not have larger protected areas here"*⑥
• *"I do not blame the farmer, as he has to make money"*⑥
• *"we have a good relationship with the farmers"*⑥
• *"50 % income from livestock farming"*⑦
• *"the greenies are a crap folk… we farmers protect the nature and not the greenies"*⑦
• *"the conservationists do not have proper work... they are lazy and stupid"*⑦
• *"we are conservationists"*⑧
• *"hunters support the reproduction of wild boar which leads to conflicts"*⑧
• *"33% income from livestock farming"*⑨
• *"we actually have no problems with the hunters"*⑨
• *"I do not know what a nature park is"*⑨
• *"I see the wildlife as comrades in the nature and I am happy when I see them"*⑨
• *"I have a neural attitude to livestock farmers"*⑩
• *"we need them for landscaping and habitat management"*⑩
• *"I prefer grazing of livestock a lot compared to industrial farming; that's why I try to establish coexistence between livestock farmers and wolves"*⑩
• *"hunting by humans represents an unpredictable threat for wildlife which has caused more nocturnal activity"*⑩
Major human-wildlife conflict associated with cattle farming
Restrictions of cattle farming through conservation
• *"most of these organizations are only interested in making money"*⑦
• *"the conservationists make their scientific studies exactly the way they need them"*⑦
• *"nature will regulate itself, it is not necessary to waste millions for nothing"*⑦
• *"now they lease the pastures to farmers and make good money by doing so"*⑦
• *"when these assholes do something, then it is good but when someone else wants to do something they want to give restrictions and ask for money"*⑦
• *"we are helpless and have to follow their restrictions to not lose the pastures"*⑦
• *"on the protected land nearly nothing is allowed"*⑦
• *"we try to avoid conflicts with the conservationists and work as they require; otherwise we have only trouble"*⑦
• *"we rent pastures from conservationists, which have purchased the land from our tax money"*⑦
• *"for livestock keepers it is prohibited to construct permanent fences but the conservationists construct massive fences in protected landscape"*⑦
• *"conservationists tried to keep livestock but had to stop it, as they could not manage it"*⑦
• *"they dictate us farmers what to do but cannot manage themselves"*⑦
• *"conservationists think that they know everything better... they are smartasses"*⑦
• *"conservationists are only interested in realizing their ideas and do not care about others"*⑦
• *"they should let the hunters decide what to shoot (including wolf and beaver)"*⑦
• *"the government is leasing farmland in protected areas to farmers, as a use is required"*⑧
• *"the category nature park is associated with very little restrictions for farmers"*⑧
• *"farmers have to manage the land in nature conservation areas (IUCN Category 4) under strict restrictions, which causes conflict"*⑧
• *"we try to find a land use form which fits our conservation goals"*⑧
• *"farmers can get subsidies through conservation contracts"*⑧
• *"the implementation of the nature conservation areas is based on long discussion for compromise finding, which was not always a good solution for both sites; conservationists pushed through their requirements"*⑧
• *"conservationists like to keep the water level high"*⑨
• *"the beaver causes more serious problems… they avoided the water from running of"*⑨
• *"in nature conservation areas the land use is restricted a lot"*⑨
• *"once conservationists wanted to buy my grassland but that never happened"*⑨
• *"we are not so under pressure from the conservationists compared to farmers further down the river"*⑨
Predation of cattle by large carnivores
• *"we should manage the wolf like neighbouring countries and shoot a certain number every year"*①
• *"we have a problem with the wolves but conservationists are too extreme and naive"*①
• *"the wolves do not fear humans and come close to house; they recognize easily when they are not hunted"*①
• *"the wolf needs a large habitat but the population is increasing uncontrollably and Germany is to densely populated by humans"*①

- *"the wolf predates livestock, since this is easier to capture"*①
- *"the wolf has been spotted in the region but I have not heard about damages here"*②
- *"I do not have a positive attitude towards wolves, since wildlife changes its behaviour"*②
- *"wolves should be shot so that they do not spread out further and threaten humans and livestock"*②
- *"I have not heard about cattle predation through wolves in our region"*③
- *"a single wolf has been spotted but I think our area is to dense populated for a wolf pack to live"*③
- *"with the single wolf I do have no problem since it has no chance against my herd of cattle"*③
- *"it will be serious when there is a wolf pack, which can bring the cattle in panic so that they break through the fences"*③
- *"the wolf can become a problem for our beef cattle for sure"*④
- *"through predation of calves and through cattle breaking out and causing damages"*④
- *"we do not have a positive attitude towards the wolf"*④
- *"I think the wolf should only stay on military training areas and when leaving these sites be shot"*④
- *"Germany is to dense populated to have space for wolves"*④
- *"we are concerned that the wolf could predate our cattle"*⑤
- *"I have captured a single wolf sometimes with my camera traps"*⑥
- *"our area is to dense populated to habitat"*⑥
- *"for the livestock farmers it is complicated"*⑥
- *"I am not happy about the wolf presence"*⑥
- *"the wolf should be hunted by the people which have protected the species"*⑥
- *"I suppose the wolves were brought here by conservationists"*⑦
- *"some farmers in the region have lost lots of calves through wolves"*⑦
- *"we have had trouble with wolves and when depredation is increasing we have to stop the cattle farming"*⑦
- *"a calf of mine was killed last year although the cattle was relatively close to the stable"*⑦
- *"when I found the calf I called the responsible person, which came immediately"*⑦
- *"he tried to convince me that the calf was sick and stories like that"*⑦
- *"I am sure that was not a single wolf… the calf was nearly completely eaten"*⑦
- *"a DNA test figured out that the wolf was responsible"*⑦
- *"finally I got compensation but it was an effort and lasted long"*⑦
- *"cases of livestock predation through wolves are managed by certain people"*⑧
- *"we as nature park management are not involved and get not informed"*⑧
- *"there were only a few cases of cattle predation by wolves in our nature park so far"*⑧
- *"we have had cattle predation by wolves on our farm and one case has been registered"*⑨
- *"the losses through cattle predation by wolves are still small but we will reach a point when we have to bring cattle inside during night"*⑨
- *"I think that there is more than one wolf since one calve was nearly completely eaten"*⑨
- *"the wolf manager came and observed the predation case"*⑨
- *"I have had more issues with predation of calves but I have not informed the wolf manager, since he did not keep promises"*⑨
- *"I did not get answer from the wolf manager and no compensation, although he promised to inform me"*⑨
- *"the wolf kills smaller calves first, but when there are more wolves they take larger calves too"*⑨
- *"when the wolf population further increases, grazing of livestock will be under strong pressure"*⑨
- *"some farmers already gave up cattle farming because of the wolves"*⑨
- *"the cattle pastures are next to the forest where the wolves life and wolves killed a calve nearly monthly"*⑨
- *"as long as I do only loose one calf a year I do not care much but every month would be a disaster"*⑨
- *"wolves were not present for 150 years and not popular before"*⑨
- *"the government as well as the society whishes the comeback of the wolves"*⑩
- *"the wolf is protected through international law (Berne Convention) and on European level (Natura 2000)"*⑩
- *"predation incidents with cattle are increasing"*⑩
- *"wolves have probably learned that calves are an easy prey"*⑩
- *"some livestock farmers which neither apply herd protection, nor ask for compensation, since they do not want to be involved in wolf management"*⑩
- *"we should protect the wolf, as we require that countries in Africa protect their dangerous large wildlife, which frequently cause mortality in humans"*⑩
- *"we in Germany as rich industrial country cannot manage the wolf"*⑩
- *"in comparison to the animals in Africa the wolf is a uncomplicated species and we have much more money thus coexistence should be possible"*⑩

Damage by naturally occurring ungulates

- *"conflict between farmers and hunters because of wild boars, which cause damage on the pastures"*①
- *"we have not had to compensate damages through wildlife so far"*①
- *"we have often damages through wild boar, particularly in maize fields and on pastures"*②
- *"some hunters give up because they are not able to prevent expensive crop damages through wildlife"*②
- *"when there are damages, the farmers report them to us and we try to commonly find a solution"*②
- *"fencing helps temporarily to reduce crop raiding... the fence has to be maintained"*②
- *"hunting and damage prevention become increasingly difficult, as the wolf causes disturbance; wildlife becomes more secretly and accumulates in larger groups to reduce predation risk"*②
- *"we have more problems with wild boar than with roe deer"*③
- *"wildlife damages pastures and crops, but we are used to that issue"*③
- *"we support the hunters but expect that they keep crop damages as low as possible"*③
- *"I have never had a serious conflict with a hunter"*③
- *"when we have a problem we talk to each other in order to solve it, that works good since years"*③
- *"when there is crop damage through wildlife we inform the hunters and they care about it"*④

- *"wild boar damages pastures from time to time but this not a problem"*④
- *"on grassland we have not had serious issues but with crops, particular maize"*④
- *"wild boar cause damage on our pasture and crops"*⑤
- *"for hunters it is also not easy, since wild boars building large groups due to wolf presence recently"*⑤
- *"there is no limit for hunting wild boar"*⑥
- *"we manage the wild boar population so that damages on farmland can occur but are not serious"*⑥
- *"only sometimes the farmers complain about damages through wildlife"*⑥
- *"in our hunting plot damages through wildlife are not serious but in other areas it is a problem"*⑥
- *"several hunters have already quit because they could not afford to pay for the damages"*⑥
- *"I find it not okay, that hunters have to pay for the unsuccessful agricultural policy of the EU"*⑥
- *"monocultures are increasing, agro-biodiversity is decreasing"*⑥
- *"wild boar accumulates in large groups due to wolf presence, which makes hunting difficult"*⑦
- *"wildlife causes damage on pasture and arable land... when I use electric fences the damage is reduced"*⑦
- *"there is a urgent need to reduce the wild boar population"*⑧
- *"the wild boar population increases dramatically but the hunters do not care much"*⑧
- *"we have significantly increasing damages on the grassland in particular in protected areas"*⑧
- *"the wild boar lives in less used habitats which are also important for endangered species"*⑧
- *"wild boars cause a decline of endangered species like certain reptiles"*⑧
- *"perhaps due to the wolf presence roe deer appears in large groups in winter, what causes crop damages"*⑨
- *"we also have trouble with wild boars in the fields"*⑨
- *"we actually have no problems with the hunters"*⑨
- *"there is no evidence that wildlife changes behavior when wolves are present"*⑩
- *"large wildlife groups can also be a result of immense availability of forage... they were also common before the wolves came back"*⑩

Practices to mitigate predation of cattle by large carnivores

- *"fences do not help to avoid livestock predation"*①
- *"in my opinion the wolf has to be hunted and this will be the case soon or later"*①
- *"a wolf was in town near the kinder garden but they did not shoot it because officials needed long time to agree"*①
- *"we have a calving season in early spring"*③
- *"perhaps cattle with horns would be an asset to fight a wolf but not a wolf pack"*③
- *"hornless cattle is easier to handle but less aggressive"*③
- *"beef cattle is calving seasonal to receive all calves in early spring so that they can be sold end of the year"*④
- *"our staff looks after the cattle at least 3 times a day"*⑤
- *"we do not have strategies to avoid conflicts with wildlife... we only have the electric fence for the cattle"*⑤
- *"we want hornless cattle for the safety of our staff"*⑤
- *"during winter cattle is close to the farm and thus well protected"*⑤
- *"it is difficult with people, which did not grew up with agriculture and hunting"*⑥
- *"I do not want to shoot a wolf, as militant animal right activists could damage my house and my car"*⑥
- *"it is just a question of time until wildlife gets used to these things but it helped for a while"*⑥
- *"we have not changed our management yet"*⑦
- *"we can apply for subsidies for fencing, but have also be maintained"*⑦
- *"from the office where no grasses are growing they decide that we need a comprehensive electric fence"*⑦
- *"it is not practicable for us, it's a lot of effort to hold back the fast growing grasses from the electric fences"*⑦
- *"we get more and more restrictions but ever less money for our produce"*⑦
- *"conservationists require fences with 5 wires, starting 20 cm above ground"*⑨
- *"farmers would have to remove the grasses from the fences permanently to ensure safety"*⑨
- *"we would have to employ 10 new staff to manage that on our large pastures, as there is no machine which we could use for this work; consequently we have not constructed the required fence"*⑨
- *"one pasture I do not mow after grazing to ensure cover for calves to hide from the wolves"*⑨
- *"I more often patrol in the area and watch out for wolves and traces"*⑨
- *"I try to protect cows with young calves, as young calves are particular endangered through predation"*⑨
- *"during winter they are close to the house and during summer I have them on a pasture with longer vegetation for calving, so that the calves can hide"*⑨
- *"one farmer here was so desperate that he parked a car in the paddock and turned on the radio loudly during night to scare of the wolves"*⑨
- *"some shepherds use dogs for herd protection"*⑨
- *"there is a new trend towards cattle with horns among farmers, which keep their cattle outside"*⑨
- *"nowadays I want aggressive cattle with horns, which can defend themselves against the wolves"*⑨
- *"I have experienced that cattle with horns is more defensive compared to hornless ones"*⑨
- *"livestock farmers would need to bring their animals into stables during night to protect them from predators, similar like in Africa"*⑨
- *"it is an issue that cattle are mainly hornless nowadays"*⑩
- *"horns would be good against wolves but also make handling of cattle more risky for farmers"*⑩
- *"it is not foreseeable that wolves will be hunted in Germany"*⑩
- *"a wolf can only be caught or killed for a few serious reasons, as strictly protected species in Germany"*⑩
- *"hunting is often recognized as alternative for herd protection but that's not the case"*⑩
- *"central wildlife management only exist for wolf and beaver"*⑩
- *"the focus in wolf management is to increase acceptance in the society"*⑩
- *"we try to take fear from the people by public relation work"*⑩
- *"we try to establish coexistence through support of livestock farmers"*⑩
- *"we have a very comprehensive wolf monitoring but the population is increasing"*⑩

- *"farmers can apply for compensation"*⑩
- *"compensation is only possible when herd protection measures are in place; this does not count for cattle, where herd protection is not mandatory"*⑩
- *"an assessor drives to the farmer and evaluates the damage"*⑩
- *"sometimes farmers try to get money through compensation when livestock died because of other reason"*⑩
- *"it is not possible to avoid predation of livestock, but it should be reduced to a minimum"*⑩
- *"farmers should look after the cattle on a daily basis"*⑩
- *"it exist guidelines for fencing; fences of most cattle farmers are not state of the art"*⑩
- *"the grass at fences has to be moved by hand; it was also thought about using herbicides"*⑩
- *"we want the livestock farmers to conduct herd protection measures and support this"*⑩
- *"we support the purchase but not the maintenance (e.g. fences and dogs)"*⑩
- *"in areas where predation is common, we recommend fences for cattle, which are 90 cm high electric fences wires (20 cm, 40 cm, 60 cm and 90 cm)"*⑩
- *"when wolves cross this fence, it has to be increased to 120 cm"*⑩
- *pastures for cattle are often large; we cannot afford to pay for such quantity of fences"*⑩
- *"net-fences are also possible to keep wolves out from pastures"*⑩
- *"we assume that cattle is well protected through its size"*⑩
- *"dogs might also be used for the protection of cattle"*⑩
- *"a well fenced pasture for calving and young calves could probably avoid most of cattle predation, as most incidents happen during the first 2 weeks"*⑩
- *"there are ideas to observe pastures automatically with drones"*⑩
- *"herd protection should be as less work intensive as possible"*⑩
- *"we advise the cattle farmers to synchronize the calving"*⑩
- *"where wolves do not predate livestock, they should not be hunted"*⑩
- *"when wolves have learned how to cross the fences, they have to be shot, even entire packs"*⑩
- *"when the wolf population gets out of control, we have to think about sensible areas where the no wolves are tolerated; but therefore we have to wait first"*⑩
- *"a massive reduction of the wolf population in a certain area would be an option to reduce damage"*⑩
- *"shooting of problem wolves makes sense, but a general hunting like we have it for other wildlife would not reduce the damages"*⑩
- *"cattle farmers mainly use a single wire, as more was not necessary up to now"*⑩
- *"it was just necessary to make cattle stay on the pasture"*⑩
- *"young calves often walk under the fence and sleep outside; that's when they are attacked by wolves"*⑩

Practices to assure ecological sustainability of cattle farming

- *"in spring the grassland is harrowed"*①
- *"the grazing of cattle ends in October every year"*①
- *"the farmers change the pastures frequently"*②
- *"the pasture is given time to recover during winter months"*③
- *"I can only keep as many cattle as I can sustain on my land"*③
- *"when I lose land I have to reduce the number of cattle"*③
- *"I have made crop land to pasture when there was not enough grassland for my cattle"*③
- *"we have reached the limit of cattle and do not want to keep more, we rather plan to reduce"*③
- *"we receive money for sustainable grassland management from the government"*③
- *"without subsidies cattle farming would not be economical"*③
- *"during summer we practice low density grazing of beef cattle"*③
- *"usually we start grazing cattle in May and bring them back to the stable at the end of October, when the pasture is finished and the offspring is large enough to be sold"*③
- *"we rotate the grazing cattle on several pastures"*③
- *"we try not to exceed a certain cattle density on the pasture; we keep 0.6 livestock units per ha"*③
- *"the 200 cows are split into 5 herds according to the size of the pasture; thus we avoid overgrazing and assure that the cattle has sufficient forage"*③
- *"the vegetation which is remaining after grazing we mow with a machine"*③
- *"during winter our cattle is fed inside the stable (gas-silage, hey and also maize from the fields)"*③
- *"we practice only rotational grazing; cattle gets fresh pasture every day"*④
- *"we try to avoid trampling damage of pasture through cattle"*④
- *"when a pasture is finished the remaining grasses are mulched to support re-growth"*④
- *" we graze the cattle from March until October"*④
- *"during night we feed the dairy cattle inside the stable"*④
- *"dairy cattle are inside during winter"*④
- *"we apply rotational grazing of cattle and start in April; pasture is changed every 2 to 3 days"*⑤
- *"we decide on the characteristic of the grassland when to change the pasture"*⑤
- *"we always feed straw as well"*⑤
- *"during winter they get a pasture close to the farm building where they get hey and straw"*⑤
- *"after grazing the remaining grasses and unwanted vegetation are mowed"*⑤
- *"when the cattle have finished the grasses, they are brought to another pasture"*⑥
- *"after grazing, pastures are mulched or mowed, so unwanted vegetation cannot grow"*⑦
- *"when a pasture is finished, cattle is brought to the next one"*⑦
- *"the cattle can always come to the stable where they get additional forage"*⑦
- *"farmers also mow the grassland to produce fodder"*⑧
- *"it is important to keep the grassland open through mowing and/or grazing to avoid succession"*⑧
- *"grazing of livestock is required and an important management tool in conservation"*⑧

- *"I harvest hey and also produce winter fodder on arable land"*⑨
- *"during the end of the vegetation period we give additional fodder to the cattle on the pasture"*⑨
- *"during winter cattle get hey, grass silage and maize silage"*⑨
- *"grazing is good against bush-encroachment... cattle eats also young trees"*⑨
- *"I apply for subsidies for low density grazing"*⑨
- *"I follow the rules but real nature conservation is not present"*⑨
- *"grazing of livestock is suppressed by industrial farming, whereby livestock is only kept in stables"*⑨
- *"grazing of livestock has become rare and is mainly practiced small scale in organic farming"*⑨
- *"I mow pastures after grazing"*⑨
- *"our pastures are divided into smaller parcels; one is grazed after the other (rotational grazing)"*⑨
- *"I sell the offspring up to three times a year"*⑨

Impact of livestock farming on wildlife presence and activity

- *"farmers use electrified fences, which are not damaged by wildlife"*①
- *"a single electrified wire disturbs roe deer and wild boar less; wildlife learns how to cross the fences"*①
- *"the wire does not disturb the wildlife when electricity is switched of"*①
- *"rotation pasture is better for wildlife"*①
- *"wildlife comes back after cattle is moved to a fresh pasture"*①
- *"roe deer is very often on the pasture when the cattle is not present and grasses spread again; it does not like the presence of cattle"*①
- *"wild boar and red deer is only present after grazing season when cattle is not present on pasture"*①
- *"the farmers use mainly electrified fences, which they remove after grazing"*②
- *"no obvious impact of cattle farming on wildlife"*②
- *"wildlife moves to neighboring pastures when cattle is grazing"*②
- *"pastures have maximum 2 ha so that the wildlife can easily walk around"*②
- *"wildlife is vigilant but does not avoid the cattle pasture completely"*②
- *"as the electric wires for cattle farming are relatively high, wildlife can pass without disturbance"*②
- *"we use permanent fences with 3 wires as well as mobile electric fence"*③
- *"roe deer gives us some trouble with the mobile fences only"*③
- *"next to this I do not realize impact on the wildlife through the grazing of cattle"*③
- *"I have not noticed that electrified fences disturb wildlife; wild boar goes under and roe deer jumps over"*③
- *"wildlife gets used to the cattle; there is no competition with cattle"*③
- *"we use 2 electrified wires for fencing (at 75 cm and 100 cm height)"*④
- *"we are not allowed to use permanent fences in the protected area"*④
- *"I have seen that wildlife crosses the fences without disturbance"*④
- *"It is obvious, that wildlife does not stand in between cattle"*④
- *"wildlife is back on the pasture when the cattle is not present"*④
- *"we use the eclectic fence, since it is the easiest measure for us"*⑤
- *"only the outer fences are permanent, important for safety at the road"*⑤
- *"inner fences are mobile and shifted from time to time, removed in winter"*⑤
- *"I guess that when the cattle is on the pasture wildlife will be on the other one"*⑤
- *"I guess there is more wildlife presence during winter when cattle and fences are not present"*⑤
- *"single pastures are fenced temporary with a single electric wire"*⑥
- *"I shot several roe deer, which had injuries probably caused by barbed wires"*⑥
- *"otherwise roe deer is not disturbed by the fences, they jump over"*⑥
- *"wild boar usually comes during night so that I cannot say much; I guess there is no conflict"*⑥
- *"there is a little bit competition between cattle and wildlife"*⑥
- *"particularly the roe deer does not like cattle presence, and thus keeps distance to cattle"*⑥
- *"wild boar lifts the fence and walks through"*⑥
- *"I think a single electric fence is the best option for the wildlife because they can easily pass"*⑥
- *"difficult are the net-fences which are used for sheep farming"*⑥
- *"a large pasture with only a few cattle is better for wildlife compared to very small pastures"*⑥
- *"wolf presence causes much more changes in wildlife behavior compared to cattle"*⑥
- *"when the cattle is inside the stable, wildlife is on the pastures"*⑥
- *"wild boar comes only during night, roe deer is often on the pasture also during day"*⑦
- *"I use only electrified fencing"*⑦
- *"when the pasture is large enough, roe deer and cattle can be next to each other; on small pastures roe deer disappears when the cattle is present"*⑦
- *"here mainly mobile electric fences are used"*⑧
- *"we have less restrictions regarding fencing"*⑧
- *"sometimes wildlife get stuck in net-fences used for sheep"*⑧
- *"the increasing wild boar population causes often destruction of fences"*⑧
- *"we use 2 electrified wires for fencing, which have obvious impact on the wildlife"*⑨
- *"when the electric power is of and the cattle is not present, wildlife is immediately on the pasture"*⑨
- *"the hunters sometimes remove our fences to ensure wildlife mobility"*⑨
- *"electric fences have a learning effect on the wildlife"*⑨
- *"wildlife is less present on pasture during grazing of cattle compared to when cattle is absent"*⑨
- *"cattle represses wildlife from the pastures as they are competitors for forage"*⑨

Lower Oder Valley

Stakeholder functions and relations
• *"I am renting a hunting plot adjacent to the national park"*①
• *"hunting conditions have become significantly worse due to implementation of permanent grazing"*①
• *"with the farmers I do have a good relationship"*①
• *"70 % income comes from livestock farming"*②
• *"I am a hunter myself"*②
• *"100 % income from livestock farming"*③
• *"we can lease land from conservationists, as they like our organic approach"*③
• *"the only species which causes trouble is the wild boar when not hunted sufficiently"*③
• *"I can report the damages to get compensation but that was not necessary yet"*③
• *"I like agro-forestry"*③
• *"we graze cattle for nature conservation"*④
• *"hunting is not restricted on cattle pasture"*④
• *"we have a company for livestock farming"*④
• *"I would like to shoot more wild boar"*⑤
• *"cattle farming restricts hunting, but this is not significant"*⑤
• *"grazing of cattle is positive for hunting"*⑤
• *"we need to cooperate with the livestock farmers"*⑤
• *"90 % income from livestock farming"*⑥
• *"once I was honoured as best landscaper, today I am the last asshole for the conservationists"*⑥
• *"I have conflicts with all the hunters, as they do not shoot enough wildlife"*⑥
• *"the only solution is to shoot the wild boar, but conservationists monitor them; lots of money is wasted for conservation measures"*⑥
• *"I am conservationist and hunter"*⑦
• *"it would be better to shoot wildlife without limitations inside the national park, as it is done for wild boar"*⑦
• *"outside the national park wildlife is promoted and inside the national park wildlife is shot"*⑦
• *"fences for livestock farming can cause mortality in wildlife"*⑦
• *"need for better coordination of livestock grazing"*⑦
• *"I am conservationist and hunter"*⑧
• *"trees can be damaged through poor grazing practice"*⑧
• *"wildlife and cattle can coexist, since cattle is relative of aurochs"*⑧
• *"need to convert agricultural land into grassland"*⑧
• *"50 % income from livestock farming"*⑨
• *"we get money for low density farming (KULAP program)"*⑨
• *"we contribute to maintain the cultural landscape"*⑨
• *"I am a hunter myself"*⑨
• *"wild boar needs to be hunted more intensively within and outside the national park"*⑨
• *"we do not have a good relationship with the private conservationists"*⑨
• *"we are not a friend of the national park"*⑨
Major human-wildlife conflict associated with cattle farming
Restrictions of cattle farming through conservation
• *"of course there was lots of trouble with the land owners, agriculture and so on"*①
• *"conflicts between interest of local people and conservation goals are present"*②
• *"the implementation of the national park was associated with several restrictions of local people"*①②
• *"there were serious conflicts between farmers and national park some years ago"*③
• *"conservationists want to reduce the fertility of the land, while for me as farmer conservation is the maintenance of soil fertility"*③
• *"nature conservation demand more natural water level to allow for minimum human interference"*④
• *"of course we hamper large scale agriculture; there was mainly a legal conflict... land conflict between conventional agriculture and nature conservation"*④
• *"we did not extend the land lease with a farmer, as he was complaining that we as conservationists have purchased farm land"*④
• *"we plan to intensify livestock grazing for marketing reasons"*④
• *"although scientifically incorrect, the name aurochs is good for the marketing of beef"*④
• *"our main income are EU subsidies"*④
• *"there is a conflict with the farmers, which used to rent the land in former times"*④
• *"the problem are the former land users, which think that their land use form is the only one"*④
• *"nature conservation should be independent from political fluctuations"*④
• *"there are the conflicting approaches of species conservation and the allowing for natural processes"*④
• *"the national park administration has no competences and is ineffective"*④
• *"there is a serious conflict between farmers and national park"*⑤
• *"conservationists wanted to destroy my farming business, as they took lots of land from me"*⑥
• *"conservationists lease their land to farmers, while they like to increase the price... they are only interested in making money to buy more land"*⑥
• *"conservationists buy farm land for high prices, which farmers cannot effort"*⑥⑨
• *"conservationists take land from farmers which do not follow their rules"*⑥
• *"conservationists force farmers to sign a cooperation contract in which they agree that the rented grassland can be flooded"*⑥
• *"I am against core areas for conservation"*⑥
• *"the area, which is national park now should be used for low density farming and fertile soils should be used for intensive*

*agriculture to sustain human food security"*⑥
- *"privately organized conservationists have already bought more than 6,000 ha land (half of the national park), the other half of the national park is owned by the federal state of Brandenburg"*⑥
- *"there is a land conflict between privately organized conservation and governmental conservation due to competition for land and the ownership of the core area"*⑦
- *"the conflict goes back to the beginning of the establishment of the national park"*⑦
- *"the national park was strictly implemented in a cultural landscape without consideration of local peoples interests"*⑦
- *"the agricultural company was founded by privately organized conservation to purchase land and is probably only economically through EU subsidies"*⑧
- *"mainly the large agricultural companies are complaining, as they can never get enough"*⑧
- *"there is an economical interests on farm land because of EU subsidies"*⑧
- *"unfertile land has only become interesting because of subsidies (common agricultural policy of the EU)"*⑧
- *"Higher water level and natural water regime would require more grazing, as much grassland cannot be mowed anymore"*⑧
- *"conflict between conservationists due to changing political interests and the implementation of core areas"*⑧
- *"private conservationists want to graze their livestock even in core areas of the national park to generate income from EU subsidies and marketing of cattle products, while the government is against livestock farming in core areas"*⑧
- *"it exists a serious conflict between the national park administration and the privately organized conservationists"*⑨
- *"the private conservationists hinder the implementation of the national park, as they are not interested in core areas"*⑨
- *"the private conservationists have become independent and do not cooperate with the national park administration"*⑨
- *"the two people, which manage the private conservation are only interested in realizing their philosophy"*⑨• *"the national park was planned without considering the local people, which caused conflicts"*⑨
- *"there is no chance for cooperation, since conservationists are no realists"*⑨
- *"this is a cultural landscape, formed through human activities; they do not protect natural landscape here"*⑨
- *"we are not against nature conservation but we need to make profit. When the consumer would be willing to pay more for food, we could farm more sustainably. I am totally against current the agricultural policy of the EU, which actually subsidizes consumers"*⑨
- *"they lease most of their land to farmers in order to generate income for buying more land"*⑨
- *"we lose pasture as it becomes part of the core area of the national park"*⑨
- *"we will lose more land to the national park and perhaps we have to quit cattle grazing"*⑨
- *"the main conflict we have, is with the privately organized conservation... they have taken lots of land from us"*⑨
- *"they buy farmland and spread like cancer... they have already purchased more than 6,000 ha"*⑨
- *"it is not reasonable, that the private conservationists conduct farming with tax money; this organization should be destroyed and the land given to the government"*⑨

Predation of cattle by large carnivores
- *"I have seen two wolves on my hunting plot several years ago"*①
- *"wolf presence is reported from time to time but we have not had any issues with livestock predation so far"*②
- *"there is no conflict with wolves here yet"*③
- *"wolves are sporadically present in the area but we have no experience with predation so far... I do not know what will happen when the quantity of wolves increases"*④
- *"I have seen at least one wolf and we found a couple of roe deer carcasses in the landscape"*⑤
- *"I got serious heart issues when I heard that wolves were spotted in the region... we have not had predation by wolves so far but it is only a matter of time"*⑥
- *"people are paid to photograph and film wolves; I do not understand what is going on, I think it is stupid. The society becomes decadent"*⑥
- *"we have no problems with livestock predation through wolves so far but the situation will change with the recolonisation"*⑦
- *"the species wolf has been proven two times in the area, further rare larger carnivores are golden jackal* (Canis aureus) *and lynx* (Lynx lynx)"⑦
- *"wolves are passing the area"*⑧

Damage by naturally occurring ungulates
- *"the prohibition of hunting during the establishment of the national park led to a high wild boar quantity and associated conflicts (crop raiding, damage of dams)"*①
- *"reduced issues with crop raiding wildlife due to transformation of arable land into grassland and intensive hunting of wild boars nowadays"*①
- *"the hunting quantity is planned by estimating wildlife populations"*①⑦
- *"we hunters pay a certain amount for crop damages by wildlife to farmers"*①
- *"we are allowed to hunt inside the national park nowadays"*①
- *"ungulates are hunted inside the national park to mitigate HWC (damages on dams for flood protection and neighboring farmland)"*②⑧
- *"the wild boar causes trouble when not hunted sufficiently"*③
- *"I can report the damages to get compensation but that was not necessary yet"*③
- *"we decide on hunting quantities on the basis of crop damage"*⑤
- *"during summer I am busy hunting at the corn fields to limit crop raiding"*⑤
- *"hunters compensate partly for crop raiding but I am not satisfied with that"*⑥
- *"the only solution is to shoot the wild boar, but conservationists monitor them; lots of money is wasted for conservation measures"*⑥
- *"I will fence my land permanently to protect it against crop raiding"*⑥
- *"wild boar is intensively hunted inside the national park, as causing damage on dams"*⑦
- *"neighboring hunting plots benefit from high wildlife populations"*⑦
- *"it exist pronounced edge-effects due to the small dimension and the thin shape of the national park"*⑦
- *"here, hunting is common in all national parks including core areas, as wildlife causes damages in forests and on adjacent farmland"*⑧

- *"roe deer is not hunted inside the national park for eco-tourism"*[2][5][8]
- *"I have extremely high damages through crop raiding wildlife"*[6]
- *"hunting is necessary to counter increasing incidents with crop raiding on neighbouring farmland"*[7]
- *"wild boar has to be hunted more intensively within and outside the national park"*[9]
- *"we also have serious damages on grassland by wild boars; the problem is increasing"*[9]
- *"the compensation of crop damages are often be paid by the hunters"*[9]

Practices to mitigate predation of cattle by large carnivores

- *"Heck cattle behave shy and more aggressive compared to other cattle"*[2]
- *"common calving at the beginning of the vegetation period"*[2]
- *"our calves graze close to the farm"*[3]
- *"we rely on an adaptable and defensive cattle breed (Heck cattle)*[4]
- *"stories, distributed by conservationists are not true; electric fences will not hinder the wolves from predating livestock"*[6]
- *"I do not believe that other animals like donkeys can protect livestock against wolves"*[6]
- *"the herd guarding dogs, which they promote here are not aggressive enough to fight against wolves; I have two herd protection dogs, which I cannot use for grazing livestock, as they are a risk for tourists"*[6]
- *"we fence the pastures for calves with electric net-fences to protect them from wolves"*[6]
- *"my cattle is hornless for saver handling, but I would prefer cattle with horns as they are more defensive"*[6]
- *"I do not have a strategy and hope it will be okay until I will retire in three years"*[6]
- *"farmers would need more dense electrified fences and additional fluttery"*[7]

Practices to assure ecological sustainability of cattle farming

- *"certain plants are not eaten by livestock and remain on the pasture"*[1]
- *"there is trampling of grassland by livestock in vicinity to water sources"*[2]
- *"we need to keep at least 0.5 livestock units per ha to get EU subsidies"*[2][4]
- *"as the livestock density is too high for the grassland we feed hey during winter"*[2]
- *"we produce hey on grassland next to the permanent pastures"*[2]
- *"the mowing of grassland to produce hey suppresses woody vegetation"*[2]
- *"damage on woody vegetation through prohibit of roe deer hunting"*[2]
- *"except from inside the national park we conduct rotational grazing of cattle"*[3]
- *"the livestock density is limited by the national park"*[3]
- *"we have more cattle on the pasture during the vegetation period and only a few during winter months"*[3]
- *"grazing inside the national park is only allowed during certain time of the year"*[3]
- *"I produce hey as winter fodder outside the national park"*[3]
- *"intensive grazing and mowing of grassland is desired by the national park during certain times in a year"*[3]
- *"during summer they graze selectively and eat the remains during winter"*[4]
- *"there is a fenced area for the mowing of grass during vegetation period as additional fodder during winter season"*[4]
- *"rotational grazing allows the grassland to recover and prevents damages of the grassland"*[5]
- *"the farming of Heck cattle does not have destructive impact on the landscape"*[5]
- *"we change the pasture after about 3 days (rotational grazing)"*[6]
- *"the electric fence is removed and put on a fresh pasture"*[6]
- *"for the young stock we try to manage a short grass pasture, which depends on rainfall"*[6]
- *"I mulch the pastures one or two times a year after grazing to avoid bush-encroachment"*[6]
- *"large numbers of goats are good to suppress woody vegetation"*[6]
- *"my cattle does not eat woody vegetation, in particular thorny species"*[6]
- *"we grow cover crops for forage on arable land"*[6]
- *"farmers receive money for sustainable grazing of livestock"*[7][9]
- *"hedges in the landscape are important wildlife shelter"*[7]
- *"a 10 meter buffer along water bodies should not be grazed by livestock"*[7]
- *"roe deer is not hunted inside the national park, although causing damage in forests"*[7][8]
- *"red deer not hunted in open landscape within the national park, here it is desired"*[8]
- *"the* concept of naturalistic grazing is not suitable to create structures in the landscape"[8]
- *"*temporal restrictions of livestock grazing inside the national park"[8]
- *"we* apply rotational grazing"[9]
- *" we harvest forage like hey and silage and feed additional fodder like maize-silage"*[9]
- *"due* to restrictions by conservationists we cannot manage the grassland intensively"[9]

Impact of livestock farming on wildlife presence and activity

- *"the rotational grazing system comprises only a single electrified wire, while three electrified wires cause reduced wildlife quantity in permanent pastures"*[1]
- *"reed areas should be excluded from pastures via fences to enable wildlife to hide"*[1][5]
- *"in rotational grazing, wildlife disturbance is limited to summer months"*[1]
- *"human presence acts as stressor for wildlife"*[1]
- *"the rotational grazing is better compared to the permanent pasture"*[1]
- *"there are no conflicts between the animals"*[1]
- *"there is little disturbance of wildlife through the grazing of cattle"*[2]
- *"I think two electrified wires are easy to cross by wildlife"*[2]
- *"roe deer get used to the electrified wires very fast and know how to pass them"*[2]
- *"fences without use should be removed, as they hinder the movement of wildlife"*[2]
- *"we mainly use one, sometimes two electrified wires and after the vegetation period fences are removed from the grassland"*[3]
- *"it could be that cattle grazing has impact on the behavior of wildlife but I think it is not significant"*[3]
- *"I believe that the animals get used to each other"*[3]
- *"the electrified fences do not considerable hinder wildlife"*[4]

- *"wild boar knows spots where they can pass easily, roe deer jump through"*④
- *"Heck cattle does not finish the grasses completely, which is beneficial for wildlife"*⑤
- *"the positive effect of cattle presence for the wildlife and hunting is, that humans stay away from the grassland and thus do not disturb the wildlife"*④⑤
- *"neither roe deer nor wild boar fear the cattle or horses"*⑤
- *"roe deer is more sensitive to cattle presence compared to wild boar"*⑤
- *"while wild boar prefers permanent pasture with higher grasses, roe deer presence is higher outside on rotation pasture"*⑤
- *"wild boar and cattle get used to each other"*⑤
- *"I have observed, that wildlife is able to handle the fences for cattle farming well"*⑥
- *"I have not had damage of fences through red deer so far"*⑥
- *"wild boar destroys net-fences for sheep when panicking"*⑥
- *"we found diverse dead wildlife caught in electric net-fences"*⑥
- *"on the pasture in the forest I use a better visible electric tape for fencing"*⑥
- *"during the beginning of grazing I put a radio to avoid wildlife running into the fences"*⑥
- *"rotation pasture uses commonly only one wire (wolf can pass easily)"*⑦
- *"the roe deer does not necessarily enter the fenced pasture they wait until the fences have been removed"*⑦
- *"the wild boar is not so much disturbed by the fences and cattle"*⑦
- *"red deer rarely enters the pasture; they can be found close to the cattle on neighboring not grazed rangeland"*⑦
- *"when the wildlife is disturbed it is only active during night"*⑦
- *"permanent fences with 2 or 3 wires can also be passed by wildlife easily"*⑦
- *"fences are particular dangerous for wildlife when it is hunted"*⑦
- *"fences can cause wildlife mortality"*⑦
- *"wildlife can damage fences"*⑦
- *"interrupt long fence lines and include passages, which allow for wildlife crossing"*⑦
- *"red deer jump over cattle fences, they slowly get used to them"*⑧
- *"after introduction of naturalistic grazing it lasted 3 to 4 years until roe deer and cattle have got used to each other"*⑧
- *"they avoid the cattle pasture for several years, but get used to the grazing system"*⑧
- *"wild boar does not care about the presence of cattle and horses"*⑧
- *"in long-term the grazing of cattle does not represent an issue for wildlife"*⑧
- *"wild boar just crosses the fences"*⑧
- *"where shepherds are with the livestock all day, even the wild boar is careful"*⑧
- *"presence of shepherd and herding dogs can avoid damages through wildlife"*⑧
- *"wildlife populations are increasing"*⑧
- *"red deer has larger habitats, thus cattle farming has less impact"*⑧
- *"wildlife and cattle can coexist next to each other, as cattle originates from aurochs"*⑧
- *"we use a single electrified wire which is removed after grazing"*⑨
- *"I think wildlife and cattle get used to each other"*⑨
- *"a second wire would have more negative impact on wildlife"*⑨
- *"wild boar is not sensible, they walk through the pasture"*⑨
- *"I guess roe deer and cattle also get along with each other"*⑨
- *"I think that the permanent fencing with electric wires has a negative impact on the wildlife"*⑨
- *"for hunting permanent pastures are nearly not able to use"*①⑤⑨

Etosha Region

Stakeholder functions and relations

- *"we keep cattle only for beef production"*①
- *"100 % income from livestock farming"*①
- *"we as farmers have no serious conflict with wildlife, we are happy when we see wildlife"*①
- *"we only do guest farm, game drives and eco-tourism"*②
- *"I have a good relationship with the cattle farmers, I think we do not have a problem"*②
- *"hunting farm"*③
- *"once this was a cattle farm and you can still find some semi-wild cattle walking around"*③
- *"50 % income from livestock farming (50 % from guest farm)"*④
- *"no conflict between cattle farming and wildlife conservation"*④
- *"we use the wildlife for game drives, we also have 2 cheetahs in a 4 ha enclosure for tourism"*④
- *"there is no conflict with neighboring farmers, as most of them farm cattle and wildlife"*④
- *"I am in the trophy hunting"*⑤
- *"we have a very good relationship with the neighboring farmers"*⑤
- *"we have no problems with anybody, we respect the other guys way of income"*⑤
- *"70 % income from livestock farming (30 % from renting out houses)"*⑥
- *"someone must produce meat but it becomes difficult to make money from farming"*⑥
- *"if it is managed properly, I think there is place for everyone"*⑥
- *"100 % income from livestock farming"*⑦
- *"coexistence with the NP would be much easier if the government would maintain the fences"*⑦
- *"70 % income from livestock farming (30 % from wildlife)"*⑧
- *"there is nothing what we get from the government for livestock losses through predation and damages through elephants, but when you shoot the animals they want to take you to jail"*⑧
- *"climate change is against us, everything is against us"*⑧
- *"25 % income from livestock farming (75% from guest farm)"*⑨

- *"we also have a lot of wildlife next to the cattle on our farm"*⑨
- *"at the moment we have a good income from cattle and tourism"*⑨
- *"100 % income from livestock farming"*⑩
- *"no one is going to compensate you, everybody is going to blame you"*⑩
- *"65 % income from livestock farming (35% from guest farm)"*⑪
- *"usually we have no problems with the conservation organizations"*⑪
- *"60 % income from livestock farming (40 % from renting out houses)"*⑫
- *"wildlife is part of the farm, we use them to make a living; the same way that I use my cattle"*⑫
- *"75 % income from livestock farming (25% from guest farm)"*⑬
- *"I do have a guest farm and I think it is more economic than trophy hunting business, but we still need to reduce the numbers and use the wildlife"*⑬
- *"I am a farmer and want the people to know the right story, and so the people understand why the farmers kill the animals"*⑭
- *"cattle farming alone is not worth to do it anymore; so farmers either farm wildlife for trophy hunting or tourism"*⑭
- *"we farmers do not really work together with conservationists because there are so many laws and regulations in place from the government side"*⑭

Major human-wildlife conflict associated with cattle farming

Restrictions of cattle farming through conservation

- *"the problem animals might come from the NP and game farms; the fence of the NP is not maintained as it used to be"*①
- *"in former times the elephants were controlled through hunting but now their numbers have increased"*①
- *"without the fence around the NP, commercial farming would not be possible"*①
- *"when they fence Etosha NP they also need to control the wildlife, but this not so practiced well"*①
- "wildlife is valuable for tourism nowadays"①
- *"poaching is a very big issue here, also of cattle because of poverty but also organized crime"*①
- *"we have a very good relationship with the wildlife we look after them"*①
- *"we are not a hunting farm, this is no option for us"*①
- *"we hunt often, we always carry a rifle in the car but we do not shoot many"*①
- *"we shoot for the school to have meet"*①
- *"we are member of the anti poaching unit and support them"*①
- *"we did hunt here before but then we decided to stop it, because that would make the wildlife more and more scared of humans but animals should be visible for the guests"*②
- *"there are some farms doing ecotourism, but most farms in Namibia are doing trophy hunting"*②
- *"poaching is sometimes a problem on our farm"*②
- *"when there is not enough grass on the farm like now, we sell animals alive"*②
- *"mostly there are conflicts between cattle farmers and wildlife farmers when the wildlife farmers do not care about the predators; I try to avoid these conflicts"*②
- *"I have no conflicts with the neighboring farmers because our fence is in a good condition"*②
- *"I support the cattle farmers because the predators catch their calf and also my wildlife calf"*②
- *"I am not so close to Etosha national park that's why the problem is not so big here; there they have problems with lions and sometimes elephants coming from the national park to the farms"*②
- *"the problem with lions mainly occurs on farms, bordering to the national park"*③
- *"when neighbours have predators on their farm, it is their own problem; there is no conflict"*③
- *"here are no compensations paid, only in communal conservancies"*③
- *"predators do not bother me, when they do not become too many; I strategically control their numbers"*③
- *"poaching is a rather small issue, as we are not located at the main road"*③
- *"hunting tourism since end of the 80th; number of hunting farms has increased"*③
- *"now much more wildlife present, as farmers look after the wildlife"*③
- *"by hunting alone wildlife numbers cannot be regulated; that works only through selling them alive"*③
- *"there are dealer who come and catch wildlife with helicopters and sell them on auctions"*②③
- *"the poachers when caught only pay a fine and start again"*④
- *"when you make charcoal you have a lot of people and then poaching starts by them"*④
- *"we regulate the wildlife populations through trophy hunting; as this is not enough, we apply for a permit to shoot the animals to sell the meat"*④
- *"selling wildlife alive is putting too much stress on the animals"*④
- *"poaching for meat is a big problem here near town; farmers at the road have the same problems"*④
- *"the number of people is increasing, but there are not enough jobs; so they look for food and income"*④
- *"luckily we are not so close to the Etosha NP; the people there have big problems with lions etc"*④
- *"wildlife is not really coming from the national park to our farm"*⑤
- *"with the predators there is a little bit of conflict with the neighboring farmers but their cattle is also conflict"*⑤
- *"I have a little bit of poaching at the road were people drive by and shoot from the vehicles"*⑤
- *"poaching is not a big problem but it might get a one because it is no more other meat available"*⑤
- *"we use the wildlife for trophy and meat hunting"*⑤
- *"in Namibia you can apply for permission to shoot leopard and cheetah every year"*⑤
- *"when I have a hunter we hunt predators, but I do not kill them unnecessarily"*⑤
- *"I do not only hunt on my property, I hunt also on the other properties where there is cattle"*⑤
- *"we have a very good management system; we are actually part of a conservancy but the government does not recognize it anymore"*⑤
- *"on the basis of game counts we decide how much we take of"*⑤
- *"I do not catch to relocate game, it is only hunting"*⑤
- *"we hunt with professional guides; we make income from both and must accept the wildlife too (you do not keep all your eggs in one basket)"*⑥
- *"we control the wildlife through hunting, mainly trophy hunting"*⑥

- *"there is a problem with poaching on the farms, particular close to towns"*⑥
- *"to make Namibia one big Etosha pan is not the solution"*⑥
- *"people want to tell us what to do, but nobody will help you as a farmer with the costs"*⑥
- *"I would open my farm for elephants when they pay me two million per year"*⑥
- *"the biggest problem is that the numbers in Etosha are becomming to high and then they come out"*⑥
- *"as long as the fences are good and wildlife stays in the national park I am fine with the management"*⑥
- *"we need the NP but the problem with farmers next to the national park is that when the fences are not in good condition, they get problems with the wildlife"*⑥
- *"what the people do not understand is, that the farmers make the living from the ground"*⑥
- *"other guys have problems with lions next to the national park"*⑥
- *"predators are good in the park for natural selection of weak wildlife but not in a farming situation"*⑥
- *"there is only one farm between ours and the national park, lions and hyenas come, if the government cannot maintain the fences, then it becomes a big problem for us"*⑦
- *"the wildlife on our farm we normally only shoot to have meat for the house"*⑦
- *"we have no issues with poaching"*⑦
- *"we utilize the wildlife too less, so populations are growing too fast"*⑧
- *"we cull the wildlife during night with a spot light for population regulation"*⑧
- *"here on my land is no poaching but in the park they poach the rhinos also on the neighbor's farms"*⑧
- *"I also do trophy hunting but nowadays not much"*⑧
- *"the farmers which do trophy hunting have problems now because there are too many of these green people complaining and lots of airlines do not transport trophies anymore"*⑧
- *"there is no hunting inside the park; they say anthrax will control the wildlife numbers but there are too many"*⑧
- *"before independence they controlled the populations of all animals in Etosha including elephants"*⑧
- *"the southern border of the NP is a veterinary cordon fence; our beef export to Europe depends on that fence (it must be always in good condition)"*⑧
- *"they come from the park... there is no fence that keeps them out"*⑧
- *"predators come from all over because lots of farms are only wildlife farms now, they breed there"*⑧
- *"some of the people are too stupid to know that the predators are there and cause losses"*⑧
- *"the hyenas come from the neighboring wildlife farm here"*⑧
- *"there were less predators in former times; the spotted hyena has increased and lions"*⑨
- *"the nature conservation interferes a lot with the natural processes; they established several artificial water holes, which was a big mistake; as a result there are too many animals and overgrazing"*⑨
- *"they already interfere when they fenced Etosha but this is necessary"*⑨
- *"the wildlife farmers tolerate the predators more than we do and then we have conflict with them"*⑨
- *"the cheetah population exploded after white people came because we create an ideal habitat for cheetahs; we kill their natural enemies (lion, spotted hyena and leopard) and provide easy food (kudu calves, cow calves, sheep, goats,…)"*⑨
- *"there are less cheetahs in Etosha than on commercial land because in Etosha is anthrax"*⑨
- *"but if you go to the Cheetah Foundation they will tell you the farmers are the biggest enemy of the cheetahs, bullshit"*⑨
- *"if I shoot a cheetah I have to report it to nature conservation for mortality statistics, which do not exist for Etosha"*⑨
- *"lions are not a problem here but closer to Etosha"*⑨
- *"hunting is completely forbidden within the Etosha national park"*⑨
- *"eco tourism and hunting tourism are not combinable in one place"*⑨
- *"it is not easy to get into trophy hunting business"*⑨
- *"only with eco tourism we will not have an income from the game unless you bring the numbers up high enough and bring a team in to shoot and sell the meat"*⑨
- *"the main issue here are hyenas and poachers"*⑨
- *"if we do not provide our employees with meat they will put up traps to get meat"*⑨
- *"we do not do trophy hunting but we buy also quite a lot of game"*⑨
- *"cattle poaching was a big issue in our region"*⑨
- *"there is not so much wildlife at the moment because oryx moved away because of the drought and kudus die because of rabies; so the populations regulate themselves"*⑩
- *"usually we harvest some wildlife for own consumption mainly, but not commercially"*⑩
- *"we are all exposed to poaching but not to the same extend that they are slaughtering our cattle"*⑩
- *"we are the 5th farm from Etosha but effectively the 3rd farm now, farms south of Etosha have been converted into tourist farms, hunting farms, game farms because that is the only way to survive"*⑩
- *"the hyenas ran back to the game farm next to us, they are very hard to kill or to get rid of"*⑩
- *"wildlife also comes from Etosha because the fences do not stop predators"*⑪
- *"there is no good management in Etosha national park because they do not maintain the roads and fences; it is like communism, nobody wants to work"*⑪
- *"poaching is a big problem, on both wildlife and cattle"*⑪
- *"we have to shoot wildlife just to bring the numbers down because they are going to die"*⑪
- *"the most problem is poaching in the area; we here have only little problems with poachers"*⑫
- *"I control wildlife populations through shooting them"*⑫
- *"I am not in the trophy hunting anymore but you have to manage the wildlife as well"*⑫
- *"wildlife is part of the farm, we use them to make a living; the same way that I use my cattle"*⑫
- *" something is happening with the hunting business, airlines do not want to take the trophies anymore"*⑫
- *"the animals go through the neighboring farms to come to me but there origin is from Etosha"*⑫
- *"to solve our issues the government must wake up because Etosha NP is so fucked up; the fence along the southern border was constructed for veterinarian reasons but now they don't maintain it"*⑫
- *" in this area we are mostly cattle farms and we strongly depend on the export of meat to Europe and thus the vet fence"*⑫
- *"there are always conflicts between livestock farmers and conservationists; the ones want to protect the predators and the other ones want to kill them"*⑫

- *"we used to be in a conservancy but it is not accepted by the government anymore"*⑫
- *"the neighboring wildlife farms do not realize the economical losses through predators on the farm; they are eating all of the young animals and when the game numbers become too little they move out"*⑬
- *"15 % of Namibia are conservation areas so it is unacceptable for me to have these predators on my farm; why must I carry that losses every night when there are vast areas for wildlife"*⑬
- *"I am not prepared to sacrifice 15 % of my produce every year without receiving one single cent"*⑬
- *"if people who want to protect them are prepared to pay for my losses than we might discuss but if not I will not protect it"*⑬
- *" hyenas come at night from the surrounding wildlife farms to hunt at my place and go back"*⑬
- *"there is no compensation you have to pay from your own pocket"*⑬
- *"conservancies in the commercial areas are not recognized by the government anymore"*⑬
- *"the farms between mine and Etosha NP used to be cattle farms; that's when I have not had a single problem with predators because the first farm south of Etosha was the buffer; they suffered but the fences were very well maintained"*⑬
- *"nowadays fences are not that well maintained and land use changed extremely; I am bordering to 110.000 ha land without cattle farming"*⑬
- *"we must protect ourselves from land use change on our costs and we do not have any benefit of that at all only losses"*⑫
- *"poaching is ever increasing due to the poor economy of the country"*⑬
- *"I don't regulate the game populations because they are moving between neighboring farms it is open and not a game fenced area"*⑬
- *"we hunt for the household"*⑬
- *"I did some trophy hunting; it can be a valuable economical option but there is a big movement against hunting all over the world; airlines do not want to carry the trophies anymore"*⑬
- *"when the wildlife is on my farm it belongs to me, when it is on the neighbors' farm it belongs to him"*⑬
- *"the small wildlife species we try to sell alive or shoot as a trophy but not for meat"*⑭
- *"the big game from hartebeest upwards to eland is better to shoot either as trophy or for meat"*⑭
- *"they do poaching a lot especially for meat"*⑭
- *"the protected areas need to improve their fences and maintain them properly, they also need to find a solution how to sterilize the animals because the populations are totally too high"*⑭
- *"predation has increased a lot because there are so many government owned farms now, where there is no control; and the lodges, who want the predators for the tourists but the farmers pay all the damages"*⑭
- *"opposite the road there is a wildlife farm, bordering to Etosha, they like it when all the large predators are on their farm because it is nice for the tourists, but these predators come to my farm when they are hungry and that is one of the main reasons why I put up the fence"*⑭

Predation of cattle by large carnivores

- *"spotted hyenas are very dangerous they have made lots of damage this year"*①
- *"populations of large carnivores have increased a lot during the last years; wildlife was weak because of the draughts"*①
- *"now there are not so many ungulates left and the carnivores predate cattle"*①
- *"cheetahs kill for fun, sometimes they kill 5 cattle and leave them"*①
- *"a leopard kills only one and comes back later; they are very beautiful but make problems"*①
- *"there are American NGOs; they catch and keep cheaters in fences and make money with tourists, which is not nice for the animals"*①
- *"when warthogs make holes under the fence it is easy for the predators to come in"*②
- *"I do not really want the predators on the farm because we want to grow up our wildlife"*②
- *"predators (e.g. cheetahs) would eat all the small lamp, which would reduce our income"*②
- *"the cheetah, leopard and spotted hyena are the ones which give us a little bit problem"*②
- *"I suppose that the lions are causing most problems with cattle farming in the area"*②
- *"problem species are cheetah and jackals; cheetahs occur in groups and only eat fresh meat; if they can, they also kill several animals and only eat a small part"*③
- *"the leopards catch the calves, that is a problem; last year I lost 12 cows"*④
- *"we do not really have lions here, the leopards do not catch cattle only little calves"*⑤
- *"predation makes it difficult to farm; our biggest problems are the hyenas, which originate from the national park"*⑥
- *"the major regional conflicts between wildlife and farming are hyenas and elephants"*⑥
- *"leopards and cheetahs are also problems but not as serious"*⑥
- *"predators and elephants are our biggest problems"*⑦
- *"we have a lot of livestock losses; hyenas are the main issue they are constantly here, lions rarely"*⑦
- *"predators come through because livestock is easier pray for the lion as wildlife"*⑦
- *"the predators are the biggest problem"*⑧
- *"main livestock predation is through spotted hyenas and lions; most losses are from spotted hyenas"*⑧
- *"leopards and cheetahs are also a problem"*⑧
- *"the spotted hyena is one of our biggest problem here to get it wiped out and cheetahs"*⑨
- *"every year we lose quite a lot of kudu calves, more than cattle calves; it is a bigger problem to the wildlife populations"*⑨
- *"commercial farmers are the biggest threat to lions in Namibia that's for sure because a lion is easy to find and kill"*⑨
- *"the spotted hyenas come from Etosha, they are more dangerous than the wolves of Europe to cattle and small stock"*⑨
- *"increase that hyenas come at night specifically when our cattle are moving around"*⑨
- *"lion is not a big problem our biggest headache is the hyena"*⑩
- *"compared to hyena and cheetah a leopard is easy to manage"*⑩
- *"the jackal can also predate calves while the cow gives birth to it or even damage the cow so that we have to put it down, so we do not like the jackal they do quite a lot of harm"*⑩
- *"hyena and leopard are the same problem"*⑪
- *"we also have problems with leopards, cheetahs and sometimes lions"*⑪
- *"the problem with the lion is when they are alone and not in a group they cannot hunt so efficiently and then when there is a calve and it is easy and she had success then she has learned to do it and she will do it again"*⑪
- *"it is mainly hyena... the numbers of the hyenas increased a lot"*⑫

- *"lions and elephants come only sometimes"*⑫
- *"there are many problems with predators, not only next to national parks but increasing all over Namibia with enormous impact on the country's economy"*⑬
- *"the hyenas are an enormous problem, areas that never had hyena problems are now reporting problems"*⑬
- *"my biggest problem with predators is the spotted hyena and then leopards and cheetahs"*⑬
- *"the spotted hyena it is a very clever animal, to manage them is very difficult"*⑬
- *"wildlife is welcome on my farm but not predators; small predators we can manage but not big predators"*⑬
- *"the hyena is supposed to be a scavenger that's why it is a terrible hunter, but now there are so many of them that they need to hunt; often cattle are not killed by the hyena but their stomachs are open"*⑬
- *"hyena is our main problem species and number two are lions and then cheetah, leopard and caracal"*⑭
- *"the predators kill a lot of my wildlife and my livestock, particular cattle"*⑭
- *"when the predators are chasing my game they jump out to the neighbors and are not mine anymore"*⑭

Damage by naturally occurring ungulates

- *"there is a problem with the elephants, they eat everything and damage our fences and windmills"*①
- *"the elephants come here from the deserts because our place has more water"*①
- *"for grazing elephants now come to the commercial rangelands and the government does nothing"*①
- *"the elephants became just to many and need to be controlled; they need to be shot as elephants and farmers cannot coexist"*①
- *"for sure elephants are also important also for tourism; we want to preserve them but they need to have their place and we need to have our place"*①
- *"the elephants cause serious financial damage, I do not like them to come here"*①
- *"farmers chase away the elephants by shooting in the air and other noise, which makes them aggressive to humans (the poor elephants, we feel sorry for that)"*①
- *"we chase them away by using a drone , they do not like that at all; that helped"*①
- *"elephants break fences and other things"*②
- *"elephants damage fences; it should be dealt reasonable with the problem"*③
- *"the former conservancies on commercial land, which were abolished by the government should remain"*③
- *"elephants should be managed by farmers; we would not eradicate them but we could make money from elephants and thus compensate economic losses"*③
- *"this would increase the acceptance of elephants by farmers, which now just shoot on them badly and hope that they dying somewhere else; that helps no one"*③
- *"the conservancy was founded to handle the elephants commonly, which is difficult now; they were not managed, as conservationists could not make decisions"*③
- *"there are too many elephants here; it is the main problem species for farmers"*③
- *"it is thought about shooting of 3 problem elephants but decisions are not made"*③
- *"luckily we have no elephants around here, but there is a problem with elephants in the Kamanjab area"*④
- *"the elephants are the main issue, they destroy a lot of fences and thus cattle comes to our farm"*⑤
- *"they must remove the elephants because we are not elephant country especially not the western side of Namibia"*⑤
- *"if we see them we shoot them to get them out of the properties they are very destructive, especially when you are cattle farmer you cannot arrange with elephants, there is no way"*⑤
- *"there are various who want them for tourism, which is good, they can have them but we don't want elephants"*⑤
- *"they are protected... but they are not welcome here in our area"*⑤
- *"they also drink a lot of water, our water ponds are not that strong they break them; they are very destructive animals so we don't want them"*⑤
- *"farmers in the south and east of Kamanjab have a lot of problems with elephants, which originate from the NP and make farming more difficult and unsustainable"*⑥
- *"elephants break the fence every day but the government does not shoot them; they say the farmers must shoot them, which is illegally"*⑧
- *"there is a problem with elephants which come to my farm from the NP to drink water"*⑦
- *"elephants break down fences and then the predators have easy access to come in and become quite a large problem"*⑦
- *"there is not much what one can do to keep the elephants inside the national park"*⑦
- *"the people here have a lot of problems with elephants, they damaged two of my windmills and some water reservoirs"*⑧
- *"I shot many elephants but illegally because it is the only solution I have, I just shoot them in the stomach that they go and die in the park, after a week you just see the vouchers turning around and nobody knows what happened to them"*⑧
- *"when you chase them away they will be back tomorrow or I shift the problem from one farm to the other but when I kill them then it is finished"*⑧
- *"maybe they are extinct in the world but in Namibia there are too many elephants and too many cheetahs, far too many"*⑧
- *"elephants migrate between countries; they can come here in large numbers and destroy everything, there is no control"*⑧
- *"the elephants can change the whole ecosystem, they break trees, bushes and grasses"*⑧
- *"there are too many elephants in the NP; conservationists say some of them must be culled but they cannot tell you how"*⑧
- *"the government is too fucking stupid to do anything about it because if they shoot one elephant the whole world will complain; they have a management plan but they do not kill them because they are scared"*⑧
- *"I got permission from the government to shoot two elephants last year but under the conditions they require it is impossible; the elephants come only for one hour; in this time you must bring together a trophy hunter and a ranger and a PH for big 5, we tried for 6 months"*⑧
- *"we had lots of problems with elephants some years ago when they kept them on the neighboring wildlife farm"*⑨
- *"all the neighboring farmers complained about it and they tried to get rid of them"*⑨
- *"they just break the game fence and our cattle fences and come in to eat trees"*⑨
- *"we had problems with elephants here, you cannot imagine the devastation; conflict with the neighboring wildlife farms"*⑩
- *"you can rather kill an human being than an elephant in this country"*⑩
- *"I had to force my neighbor to get rid of the elephants; they certified them as problem elephants and shot them"*⑩
- *"it is not a nice to see an elephant down but you feel like that when they cause you damage and nobody is willing to pay*

you any compensation"[10]
- *"we have had the elephants here three times but it is not a problem"*[11]
- *"elephants come only sometimes"*[12]
- *"I fortunately do not have many problems with elephants; they never come with a big herd"*[13]
- *"their numbers are not controlled at any means; that's why the elephant population is increasing extremely"*[13]
- *"unless a elephant is killed by a rifle there is no enemy to the elephant"*[13]
- *"I think it is not a question of just protecting the animals but to manage them"*[13]
- *"I can only have a certain number of cattle on my farm the rest I must destock if it is less rain and sell it and the same counts for the wildlife; wildlife cannot just accumulate in numbers to the expense of the neighboring areas, it must be managed as well"*[13]
- *"Botswana is starting elephant hunting again because they have 130.000 elephants in the country"*[14]
- *"during the last 10 years I have had only three times elephants on the farm, it is not a serious problem like on other farms closer to Etosha"*[14]

Practices to mitigate predation of cattle by large carnivores

- *"we have no compensation system because the government has no money"*[1]
- *"we do a lot against the carnivores, everything is allowed; in Europe they would shut down our business therefore"*[1]
- *"we farmers have to protect ourselves, so we try to shoot them, but they are smart, so we use traps and poison them"*[1]
- *"we cannot protect the cattle since pastures are to large"*[1]
- *"some Americans propose guarding dogs and donkeys, but the cattle does not stay together in one herd, so where should the donkey walk to; that's all only theory and stupid talking and not practicable at all"*[1]
- *"we control the fence every day to see what is going in and out; we close the holes under the fence and so on"*[2]
- *"the owner of the farm said we must try electrified fencing, but it is not working because the wildlife will damage the fence and make it stop working; so you must also go every day to fix it"*[2]
- *"it would be an option to sell a predator to a hunting tourist"*[2]
- *"what I do, when I go to the field every day I take my gun with me and if I find them I kill them"*[2]
- *"I have 23 traps in the field; if we catch them we can give them to the Cheetah Foundation, but sometimes the predators do not go into the traps"*[2]
- *"monitoring them would also be an option; if you see that they do no damage then I would like them for the tourists but when you see the predator is waiting for pray at the waterhole you could chase them away to protect the small wildlife"*[2]
- *"electric fences are not the thing to do, as carnivores can learn to cross them"*[2]
- *"electric fence is close to the ground to avoid undergoing but predators learn to jump over fence"*[2]
- *"electric fencing is costly to construct and cost also money every day to maintain it"*[2]
- *"the warthog for example does not worry about the electric fence and cause damage during night"*[2]
- *"I never heard that anybody got money from the government for livestock predation"*[2]
- *"strategies of the cattle farmers are similar to mine; they are using traps and drive every day with the gun to shoot predators when they find them"*[2]
- *"predators are protected but farmers are allowed to kill predators when they cause damage"*[2]
- *"it is not nice to kill them all, that's why we use the traps and try to catch them; the wildlife foundation can take them"*[2]
- *"we do not want the predators on the farm, so every day we are on the hunt for them and try to catch them"*[2]
- *"our fence is more than 3 meters high"*[2]
- *"we do not use electricity anymore because it is not cost effective; if you do not maintain the fences every day the electricity will not work"*[2]
- *"it could work perhaps on a small area but not for long distances (we have about 30 to 40 km)"*[2]
- *"the electricity in the fence decreases with the distance for the power point"*[2]
- *"I use goats as indicator to save valuable wildlife species; when a goat is missing I know that I have to do something against the carnivores"*[3]
- *"the carnivores are not trapped but disposed, so that they do not come back"*[3]
- *"commercial farmers shoot about 150 lions per year"*[3]
- *"it is legal for farmers to kill carnivores when they predate livestock, this has to be reported within 24 hours"*[3]
- *"when there are too many lions, permits for trophy hunting are sold"*[3]
- *"we look for and take care of our cattle every day"*[4]
- *"when the leopard predates our calves we go and look for him"*[4]
- *"sometimes the government send people when we call them, when not we take the law in our own hands"*[4]
- *"there is no compensation for damages through wildlife, the government has no money"*[4]
- *"you can get a permit to shoot them"*[4]
- *"we do not use electric fences because they are too expensive and labor intensive"*[4]
- *"the cattle we count every week when we move them from one pasture to the other"*[4]
- *"2 years ago we shot 2 leopards, they were with the cattle in the kraal"*[4]
- *"the neighboring farmers will also shoot them when they do damage"*[4]
- *"we do not shoot them when they do nothing"*[4]
- *"the sheep are in a kraal close to the workers houses during night"*[4]
- *"during day there is a herder with the sheep"*[4]
- *"we do not use traps to catch predators on our farm"*[5]
- *"we are not supported by the government at all, there is no compensation, nothing"*[5]
- *"farmers put the calves in a kraal close to the house if the predators are a problem"*[5]
- *"the calving is seasonal, so the management of the calves is better to control"*[6]
- *"I think when the cows are calving in a group they are more protective"*[6]
- *"there is no other choice, we shoot the predators but as they are nocturnal it's difficult to get them"*[6]
- *"leopards and cheetahs are easy to get but hyenas are the biggest problem"*[6]
- *"my young cattle is sleeping in a kraal every night and grazing only during day; that works 100 % but it is not the best way to do it because they have only up to 7 hours to graze"*[6]
- *"there is two ways to improve coexistence; one way is to farm around the predators but that's not the one I prefer (like*

putting cattle in a kraal during night... that's not sustainable because you need two times more workers and it is not suitable especially in the mountains to bring them in every night) best is to get the hyenas out like in previous times"⑥

- *"we must distinguish, is this a park or a farming area; in a farming area you control it like a farmer"⑥*
- *" no compensation system... there is no money in the country and a system like this would be open for a lot of corruption"⑥*
- *"we are allowed to shoot the lion once they start catching something"⑥*
- *"there is also the way to take the animals back to Etosha where they belong but I do not think it is sustainable"⑥*
- *"against the predators we are building kraals with thorn bushes"⑦*
- *"we have three to four people who take care of the cattle"⑦*
- *"we use dogs as well to scare predators away"⑦*
- *"during night the animal sleep in the kraal close by the peoples house"⑦*
- *"they can also make fires to keep the predators away, but the predators from the park are used to people and fire so they are not scared of that"⑦*
- *"during day they go grazing and are vulnerable"⑦*
- *"there is no compensation for livestock predation at all"⑦*
- *"when a lion catch a cow you have to report to the government, they come out and look, they say we will be back to take the lion back to Etosha but they never come back to take the lion out and never come back to take the elephant out"⑦*
- *"if you do not take the things into your own hand you will not have many cattle left"⑦*
- *"they are problem animals for our livestock and livelihood, they are dangerous for the people as well, so we take them out, we shoot them"⑦*
- *"we are allowed to kill a problem predator but you must report it immediately and they will come to inspect that; therefore they have vehicles and time and employees to do that but when you are in trouble and need their assistance to come and take it out before you shoot it then they do not have vehicles and do not have fuel they have plenty of excuses (Ministry of Environment and Tourism)"⑦*
- *"we use all kind of traps and also poison, if you do not use them you will not survive in this environment"⑦*
- *"the poison is called strychnine but you cannot get it anymore so it makes it difficult"⑦*
- *"with all these methods we can manage the predator problem a little"⑦*
- *"our government do not subsidize anything not like in Europe"⑦*
- *"conservationists tried electrified fences in some areas but they do not maintain it⑦*
- *"it is quite expensive to fence a farm because you need a lot of material and for maintenance you need a larger amount of employment to remove the vegetation underneath it"⑦*
- *"I did seasonal calving but when pregnant cows are chased around by predators they get abortions, so you can not apply the unnatural seasonal calving because you would have less cows calving"⑧*
- *"a leopard will only kill one calve and eat on it for a week... so I tolerate the leopard but cheetah I shoot them on the spot... they go into the kraal and kill 20 or 30 sheep and eat just a little bit"⑧*
- *"if I see a cheetah I will even overrun it with my car and if I damage the car I do not worry"⑧*
- *"some of them sleep in a kraal but you cannot put all of them in a kraal it is a too big operation, I don't have the people to do it"⑧*
- *"once in a week I sleep with the cattle, and try to shoot the hyenas, but I am not very successful with that"⑧*
- *"I make a fire and I also have solar lights"⑧*
- *"I identify the places where the cattle sleep (mostly in a corner of the camp), I open the place up with the tractor and put cow manure on the invasive acacia bushes all around it and set them on fire during night; lions are not very afraid of it but hyenas stay away"⑧*
- *"I also try to catch them with traps but it is not easy"⑧*
- *"when you kill a predator like a lion you must report it within ten days afterwards"⑧*
- *"my farm is high fenced around but this is for the game not for the predators, the predators go in everywhere"⑧*
- *"jackal we do not kill and we do not trap it and we do not use poison because we have the feeling that a healthy jackal population on the farm is essential to keep down the caracal population... reduces the rodents, snakes and hare and even the young cheetahs"⑨*
- *"but the hyena gives us trouble, there is not really a strategy because we cannot go to the neighboring farms to hunt them where they have their dams"⑨*
- *"predation has to happen first, then we can go and sit at the carcass and try to call the hyenas or if we suspect that there is movement because we see their tracks we can take the stomach of an animal and drag it around and sit and call"⑨*
- *"with cheetah there is not much you can do, you can set up cage traps and hope it will go in but they become clever"⑨*
- *"when we catch a cheetah and we do not want to kill it we call the Cheetah Foundation but our experience is they will come back"⑨*
- *"we try to give them to these organizations but I am not sure what they will do with them"⑨*
- *"if they tell you they resettle cheetahs successfully don't believe them that's bullshit, they just release them somewhere else"⑨*
- *"there was no cheetah in former times on our farm, there are rumors of farmers who have seen the ... (NGO) cars parked alongside the roads with empty cages on the back and sometimes even seen them opening the cages"⑨*
- *"we do not protect our livestock against hyenas during night because the problem is not that big; we would have to employ people to look after the cattle during night, which is not economically"⑨*
- *"there is no compensation when livestock is killed by predators here"⑨*
- *"you cannot protect the cattle during night, the only protection I give is to the cows with the young calves"⑩*
- *"to minimize losses all cows have to come close to my home for calving, we look at them about every two hours and the moment the calve hits the ground we put it in a small camp around the house where the dogs are and the chance of predation is very small; here we look after them until they are 4 days old"⑩*
- *"an important characteristic of Brahman cows is, that they are very aggressive when they have young calves, it is hard for a predator to grab a Brahman calf when the cow is nearby"⑩*
- *"we dehorn the cattle; I do not believe that the horns contribute to the success of which they defend themselves"⑩*
- *"some organizations in this country which portraying themselves as doing a hell of a job in conservation using our farmers and portraying them as a threat to all predators in Africa in order to get donations from abroad"⑩*
- *"we don't like cattle with horns because they insure each other during transport"⑩*

- *"we shoot the predators on site because it is not easy here to combat predators, so if we run into a predator whether it had killed something or not we kill them"*[10]
- *"you ambush the lion at its own bait and get rid of it, there is no use trying to take it back to Etosha it will just come back"*[10]
- *"leopard is very easy, because it returns to its pray and you can put a cage or get a hunter from aboard that helps to recover some of the money which you have lost; you can also put out bait"*[10]
- *"when it killed one of your animals you are entitled to have the predator removed"*[10]
- *"we use also cage traps and sometimes leg traps but then you sometimes have to kill an untargeted animal, so we do not prefer that but sometimes there is no other option when they do not go into the cage"*[10]
- *"the predators I killed they have got what they deserved; they are all guilty killing our livestock"*[10]
- *"we shoot them first and then report it, there is no time to report first when we run into them; we need no evidence because we are fulltime farmers, they take your word"*[10]
- *"I shot the lion after it killed several livestock"*[11]
- *"I can handle one % loss with predators per year; profits in agriculture are small"*[11]
- *"when an animal endangers your live or your livelihood you can shoot it but you must report it"*[11]
- *"I have a few cows with horns; it was an experiment but it didn't work, the hyena eats them with horns or without horns"*[11]
- *"near the house the problem is not so big, so I de-bush the camps around my house and I bring all the cows with small calves or the pregnant cows that are near birth to the house"*[11]
- *"in a dry year like this there is completely no grass around the house then I have to take them further away and then the problem starts"*[11]
- *"I plan to produce some good food in the rainy season and to store it so that I have more food near the house for the cows with calves"*[11]
- *"there is nothing like compensation for livestock predation"*[11]
- *"I don't use the poison, only sometimes for jackal, they become so clever as only the most clever ones survived"*[11]
- *"some farmers say they caught a cheetah and they gave it to one of the NGOs, which have just released it 10 km from where they put in the cage"*[11]
- *"so if you really want to make relationships bad with the farmers you must do this, because now you have a bigger problem because this animal now avoids traps"*[11]
- *"you cannot protect the cattle during night it is too big effort"*[11]
- *"there is no compensation for predation at all"*[12]
- *"nowadays I have to put in 2 dogs to watch my sheep and I do not have problems with cheetahs anymore"*[12]
- *"the predators we shoot them if we find them and otherwise I put out poison and traps"*[12]
- *"it is impossible to protect the cattle because they live in the field, I have many cattle and it is not possible to bring all of them to the house"*[12]
- *"the ideal way would be to bring highly pregnant cows to the house in a small camp where you can watch them but the facilities are not always there and you would have to monitor all the cattle every day, so it is better for me to do electrical fencing and keep the predators out but the first option is to get rid of them"*[12]
- *"I use electrified fence, which is only to keep predators out of my farm, because Etosha is not far from here and especially the hyenas come in"*[12]
- *"the fence at the border is a 18 wires life game prove fence 2.4 meters and I put 3 electric wires attached to the high fence at the bottom"*[12]
- *"the electric fence works, but it is not predator prove; when they want to come in, they take the shock from the electric fence and steel my cattle"*[12]
- *"outside of the NP the hyena have not got an enemy like lion and thus they are just increasing; I think we have a responsibility towards nature to manage and maintain, we cannot just have one single predator increasing in numbers… everything must be in balance"*[13]
- *"I will upgraded and electrify my fences soon, but I am not convinced that it will be that effective; it is to labor intensive because every day you need to maintain the fences"*[13]
- *"seasonal calving is better for marketing but not necessarily an advantage against predation"*[13]
- *"sometimes we must sleep outside in the field, which is time consuming and harsh for the whole family"*[13]
- *"my small stock is herded and in fences during nighttime so I have very little losses at the small stock, but you can only do it with the small stock, with cattle it is not economically"*[13]
- *"you will not have the growth and production plus additional labor costs"*[13]
- *"the cattle is not adapted so they lay at the waterhole during day and graze during night"*[13]
- *"so you need to protect it from the predators, you need to manage the predators, which is very difficult because they are on the neighboring farm; they come to my farm and kill and go back"*[13]
- *"we drive around with the rifle and try to find the predators"*[13]
- *"I have tried cattle with horns but I do not find it so effective, two hyenas they do not care at all"*[13]
- *"I also bought a donkey with a filly and the filly was caught by the hyena first before they killed the calves"*[13]
- *"NGOs come and pick up caught predators but they have so many that they cannot feed them and then they release them in areas where they are not common; so you can find rather tamed cheetahs with absolutely no natural manners"*[13]
- *"the NGOs are begging for money all over the world and they do it emotional; they say they are protecting the cheetahs but they use all the donor money for their luxurious lifestyle (buy vast areas of farmland, drive around with luxurious vehicles); not a single cent goes to the people who carry the losses"*[13]
- *"they still tell the people that predators are endangered so what have they been doing for 30 years with all of the millions of money which they have got through begging... and why is predation increasing"*[13]
- *"we try to keep the predators out of the farm"*[14]
- *"we catch the predators and put them in captivity because; to take my predators back to Etosha is so much paper work from the government; before I would do all that paper work I would kill them"*[14]
- *"I want to tell the people why the farmers kill the predators"*[14]
- *"I have put a game fence (2.4 m), an electric fence inside and outside (1.7 m) and now want to also put jackals prove fence (1 m) around the farm; this will stop predators to 95 % but still not 100 %"*[14]
- *"it costs a fortune to keep your animals inside and the predators outside and the maintenance is very labor intensive"*[14]
- *"sometimes we have to kill the predators, there is no choice we shoot them"*[14]

- *"with the cage traps we can keep them alive but sometimes we use the foot traps and then we have to kill the animal because the leg is insured"*⑭
- *"we don't use poison because the problem with poison is that too many other animals will die"*⑭
- *"the sheep we have inside a kraal close to the houses during night"*⑭
- *"when I keep leopards and cheetahs on my farm I make 100 % sure that they cannot escape. If my neighbors would do the same there would be no problem"*⑭
- *"without a population control there will always be a conflict or the government must start paying the farmers; compensate the entire market price of the lost cattle, there is no compensation"*⑭
- *"predators first stopped me from livestock farming and then they stopped me from trophy hunting; they forced me to go into tourism business"*⑭
- *"I have to spend millions to be able to start farming again on my farm"*⑭
- *"I start a little bit farming now and will increase the amount of livestock when I have put the jackals prove fence completely around the farm"*⑭
- *"the conservation of large predators (particularly cats) is money making; these NGOs live from donations, coming from outside Namibia (e.g. America); the money they spend for private use like buying farms, wine farms, lodges all that kind of stuff; only a little bit of the money goes to conservation"*⑭
- *"the problem is that the NGOs do not tell the truth, they give totally wrong information to the people, they can touch the animals and play with them"*⑭
- *"I am totally against that idea of giving wildlife a name, it is not a pet it is wildlife"*⑭
- *"there is also corruption going between these foundations and the government"*⑭
- *"a guy, which was working for one of these organizations told us when the money is running out they put the cheetahs in a small cage without food and water and make a video, telling that the animals are hungry and thirsty, and then they send it over (social media) and say that is what we get from the farmers"*⑭
- *"anyone is jumping on the car when they say the farmers kill all cheetahs; there are no cheetahs anymore in Namibia, but I think Namibia is one of the countries with the most cheetahs in the world, the same with leopards and other predators"*⑭
- *"it is not good to blame all the farmers like that, but so they make money, that is the truth"*⑭
- *"the farmers union, they want to have a meeting with these NGOs, but anytime they refuse"*⑭
- *"the problem with these NGOs is, when they collect a cat, they drive about half a kilometer and release them again on the farm, so why should the farmers call them?"*⑭
- *"we have had groups of tame cheetahs on the main road, they release them next to the farms because it is very easy for them and so the population of cheetahs on the farms is increasing"*⑭
- *"other farmers call me often and ask if I would take their cheetahs because they don't want them to give to ... anymore; they do not want to give it to ..., ... or ... because they don't trust the people and rather shoot it"*⑭

Practices to assure ecological sustainability of cattle farming

- *"rotation of grazing over the year to avoid overgrazing"*①
- *"normally we sell the cattle with an age of about 2 years; during the last years we had to sell them with 6 months already because we do not have enough grasses"*①
- *"we focus on make survive the cow herds, to continue after the drought"*①
- *"we apply low density farming; nowadays it is only one cattle per 30 ha"*①
- *"our region is not extremely encroached by bushes"*①
- *"we do not burn the pastures; the bushes are good; they offer also pasture for cattle"*①
- *"during drought it is the only available pasture and rescues the cattle"*①
- *"other farmers spray their land by airplane and have no forage when it is not raining"*①
- *"herbicides are only functioning short term and they can affect the groundwater too"*①
- *"we mow grass to produce hey, but this is only possible in years with good rain"*①
- *"we rent grassland in the east of the country"*①
- *"cattle we can transport and sell but game is starving"*①
- *"saving of grassland does not help in droughts like this one"*①
- *"many have changed to guest farms hunting farms or charcoal production"*①
- *"the cattle farmers have intern fences (camps) and they can organize the rotation"*②
- *"there is a problem with bush encroachment but I think that is naturally here"*②
- *"bushes are getting more but we not do anything against it at the moment but I think in the future we must do something"*②
- *"fire is not a good thing because the wildlife is fenced and cannot escape"*②
- *"I think the best would be poison by hand in smaller areas"*②
- *"we feed the wildlife because of the drought, we buy the feed"*②
- *"we buy feed from other regions to support the wildlife"*③
- *"we cannot save enough fodder for future droughts"*③
- *"bush encroachment is a general issue and increases mainly in years with high rainfall"*③
- *"a loader with a big iron roller is used to flatten the bush, which dies afterwards"*③
- *"afterwards lots of small bushes are growing which is even more dense than before; this small bush must be burned when grasses are present"*③
- *"fire is natural and was effective in former times; it has to be used careful and well planed"*③
- *"we will set up containers (green sprouts feeding system; drought-proofing solution for livestock farms) on the farm to produce food for the animals"*④
- *"seasonal calving is good to better adapt it to the rainfalls"*④
- *"during droughts we by additional feed like Lucerne"*④
- *"we apply rotational grazing"*④
- *"at the moment where there is no grass, the cattle eats only bushes like mopane"*④
- *"we clean the pastures with loaders but do not use fire because that would damage a lot of small animals"*④
- *"we burn the bushes when we have collected them"*④
- *"during the drought we try to reduce the wildlife numbers but there is no market, because all farmers have to sell now"*④
- *"there are different strategies to counter bush encroachment… some farmers use loaders, other burn them"*④

- *"when there is not enough rain the farmers reduce the number of cattle"*⑤
- *"we feed the wildlife, especially now in this time of the year"*⑤
- *"we do not have water to produce the feed so we buy it"*⑤
- *"we produce charcoal to reduce bush encroachment"*⑤
- *"we do not make too much money out of the charcoal but it covers the costs"*⑤
- *"we do not burn the bushes because it the risk is too high to burn the neighbors farms"*⑤
- *"we have a rotational grazing system which depends on the availability of grasses"*⑥
- *"when there is more grass the herds are bigger compared to when there is less grass"*⑥
- *"during drought grazing management changes, then I reduce the amount and mainly keep female cattle"*⑥
- *"the cattle is still grazing in the camps, where we give additional feed made from young bushes"*⑥
- *"we cut bushes and mix them with other cattle feed, which we buy"*⑥
- *"when feeding becomes too expensive I slaughter the cattle to reduce the numbers and wait for the rains"*⑥
- *"bush encroachment is a big problem; it could be from overgrazing"*⑥
- *"bushes are stimulate through the drought; there is no grass for competition"*⑥
- *"I did poison the bushes 10 years ago, it worked good but the small bushes are growing again"*⑥
- *"we have a lot of browsers among the wildlife but it is too much for them"*⑥
- *"to start fire there need to be a lot of grass, but when you have the grass, you do not want to burn it"*⑥
- *"in the past farmers used fires, it works but you need certain conditions and knowledge"*⑥
- *"one third of my farm I do not use for grazing cattle but there is nothing"*⑥
- *"many people also started charcoal production and other things to survive"*⑥
- *"I have a lot of herds and they rotate within four camps around a water post"*⑥
- *"we decide on the carrying capacity"*⑥
- *"normally there are 4 different camps, which all lead to a water point, so we make sure that we do not overgraze"*⑦
- *"we sell the calves when they do not need milk anymore; we want many calves to have a cash flow all over the year"*⑦
- *"an old saying: walk with your cattle and see what your cattle eat and you will know if there is still enough food for them"*⑦
- *"bush encroachment has nothing to do with overgrazing, naturally fires always controlled the bushes but nowadays we need the grasses for our livestock, thus we put fires out as soon as possible"*⑦
- *"we use the bushes to get some income through charcoal burning"*⑦
- *"little bushes we cut and do not burn to improve soil fertility"*⑦
- *"branches with thorns are laying on the ground and give rare grasses a chance to grow and produce seeds"*⑦
- *"the bush will maybe come again later but goats are a very good controller of small bushes"*⑦
- *"charcoal burning and goats work quite good, we do not use fire and poison"*⑦
- *"I prefer that the bushes come out again because so the goats have food again"*⑦
- *"when you use a big machine you cannot kill the bushes as selective as by hand"*⑦
- *"we adapt the grazing density to the available pasture"*⑦
- *"during droughts we need to reduce the amount of cattle to have enough grazing"*⑦
- *"mostly we try to keep our cows because they can produce the calves quite fast when the rain gets better"*⑦
- *"we try to sell the rest if the prices are good"*⑦
- *"we buy most of the food"*⑦
- *"we produce Lucerne ourselves, but only on a small-scale, as water is limited"*⑦
- *"we have rented some grazing on a neighboring farm and move our cattle to that site"*⑦
- *"each group of cattle has about 6 camps where I rotate them"*⑧
- *"I am reducing my head of cattle to the half now because of the drought"*⑧
- *"we do not put fires on the farm to control bushes because we need the grass for the livestock"*⑧
- *"fire is a very good way to control the bushes but it doesn't work without grass"*⑧
- *"we only use chemicals to control the bushes but I do not have a big problem"*⑧
- *"I make so called bush feed, but you cannot feed all the cattle with bush feed. it is impossible; I only feed 20 cattle at the time until they are fat and then I sell them"*⑧
- *"we have to buy the maize and molasses to mix it with the bush"*⑧
- *"we also grow Luzerne but it is to less to feed the cattle"*⑧
- *"we try to have at least 3 camps at a water point but there is no rotational grazing during drought"*⑨
- *"in rainy season it would be ideal to rest a camp for 120 days but this is impossible without rain"*⑨
- *"we try seasonal calving, when the calves need more milk should be in the green season but it is not possible nowadays"*⑨
- *"in Europe it was different, people must prepare for winter times"*⑨
- *"bush-encroachment is a problem but not like on other farms because this farm was never overgrazed"*⑨
- *"in former times we moved the cattle to other regions during droughts"*⑨
- *"for goats you need a very strong fence and predators will preferably kill them, which makes it difficult"*⑨
- *"we cannot produce fodder because there is no water, so we buy it"*⑨
- *"we are trying now making bush feed"*⑨
- *"we just give it to the cattle, which we want to sell to improve their condition"*⑨
- *"the females we want to keep"*⑨
- *"we could put the cattle in a kraal during rainy season and feed them bush feed"*⑨
- *"or we could combine rotational grazing with feeding in kraals; so that the grasses have a chance to grow"*⑨
- *"we have reduced the number of cattle by much more than 50 % because of the drought"*⑨
- *"bush encroachment is definitely increasing"*⑨
- *"fire is the cleanest way to de-bush, but not chemicals"*⑨
- *"with the drought we have not enough grass to burn, there will be no fire without grass"*⑨

*"poison the bushes is the most effective way but it is expensive and there is something in that what Germany wants to ban completely and then there is some reason for it"*⑨

- *"also de-bushing by using big machines is expensive and the bush just grows back"*⑨
- *"it is not because of wrong grazing methods, overgrazing and so; the grazing method is rotational grazing, which is the*

*right way to do it but we took fire out of the system because fire burns grass and grass is money"*⑨
- *"before the white people came to Namibia grass fires were very common every year in springtime; it needs fire to change the farmland back to an open savannah"*⑨
- *"naturally there was seasonal wildlife migration and grazing pressure depending on rainfall"*⑨
- *"we try to rest the pastures during the rainy seasons but we have had no rainy season"*⑩
- *"we usually reduce the number of livestock during droughts; at the moment we have about 40 % of the normal stocking"*⑩
- *"usually we do not feed the cattle but sometimes we have to feed them"*⑩
- *"we do rotational grazing; the rotation depends on the availability of grass"*⑩
- *"we have strict breeding seasons, the calving season is supposed to be when there is something green for the mother to eat but now for some years there is nothing green; so it is very difficult"*⑩
- *"we also produce some Lucerne but to a very limited scale; water is limited"*⑩
- *"the bush encroachment is a big problem"*⑩
- *"we are very scared of fire because it is hard to control; you are in trouble when your neighbors farm starts to burn"*⑩
- *"you need a lot of permits to clear and use the bushes, even to produce bush feed"*⑩
- *"we applied chemicals from an airplane, it will kill everything but if the season is long enough the grass will grow again"*⑩
- *"we used the wood; I do charcoal burning and produce fire wood"*⑩
- *"in order to cut grass for making hey we also saw better grass species but the drought ruined that"*⑩
- *"for regrowth we use machines to make bush feed, but you have to supplement that; we have to buy some ingredients"*⑩
- *"problem species: red thorn (*Acacia reficiants*), black thorn (*Acacia melithera*) and sickle bush (*Dichrostachys cinerea*)"*⑪
- *"with mechanical methods you stimulate them, they grow even more when you disturb the roots"*⑪
- *"when it rains, the grass is such an effective competitor, the bush has no chance"*⑪
- *"I have not started the bush feed yet but the machine is on its way and supposed to be here next week"*⑪
- *"it was savannah in former times; there were many bush fires from lightning but now when there is a fire we put it out"*⑪
- *"the fire must be hot enough to kill the bush, but when you have long grass it is very dangerous"*⑪
- *"I would like to do it because it is cheaper than this chemicals"*⑪
- *"I do not produce charcoal because you need a lot of workers on the farm, which could do poaching"*⑪
- *"I treated only the thick acacia bushes with chemicals by hand then the grass production just explodes; I had more grass than my cattle can eat"*⑪
- *"grazing mostly depends on the rain but it is always good to do rotational grazing, that helps a lot to avoid overgrazing"*⑫
- *"when you keep them on one pasture only, they will totally sweep out the sweet grasses"*⑫
- *"in a dry year like this you cannot do grazing management you have to use everything to keep the cattle alive"*⑫
- *"I make bush feed to fatten cattle in a kraal; then I sell it to reduce the number of cattle"*⑫
- *"we do not have really a problem with bush-encroachment"*⑫
- *"we must be careful, if it is not raining, there is no grass. but there is still bush and you can use the bush to make fodder"*⑫
- *"I did charcoal production many years ago but not to debush the farm, but to make a living from"*⑫
- *"cattle is rotating between 8 camps on a two-weekly basis, so after two weeks of grazing the camps have time to rest"*⑬
- *"it is better for pasture to have strong grazing for a short period and longer rest periods"*⑬
- *"certain bush species are more aggressively encroaching than others"*⑬
- *"I tried to use wildlife browsers but they did not have that impact what I thought they would have"*⑬
- *"we do it mechanically and utilize the bush for fodder, which is a very good thing in that dry cycle"*⑬
- *"it is costly because you also need to at energy in form of maize or something like that"*⑬
- *"I tried charcoal production but I did not like it; it uses the big trees rather than the shrubs"*⑬
- *"I apply chemicals manually to do it selectively"*⑬
- *"due to very low rainfall we have not had field fires in that extend that it could diminish"*⑬
- *"my farm burned of twice during the last 30 years due to natural fires and it didn't had big impact on bush encroachment"*⑬
- *"it is possible to manage the bushes with fires but this is dangerous and grazing is so expensive"*⑬
- *"goats are very good in utilizing the bush but unfortunately there is no market for goats"*⑬
- *"wildlife farms have the same problem with bush encroachment like livestock farms"*⑭
- *"farmers struggle so much to survive so they put too many animals on the farms"*⑭
- *"I did charcoal burning to control the bush but that did not work at all"*⑭
- *"these days I put poison out to control the bushes on my farm, this is the only way it will work"*⑭
- *"we will use poison only on half of the farm, as game need bush"*⑭
- *"we cannot use fire because we need the grass for the animals"*⑭
- *"there is always a risk that the fire gets out of control and jumps over to the neighbor"*⑭
- *"fire is especially difficult with wildlife, as you cannot move them like cattle"*⑭

Impact of livestock farming on wildlife presence and activity

- *"all farms struggle now through the extreme drought and not through overgrazing"*①
- *"the entire country is affected and many farmers will quit cattle farming"*①
- *"our fences are not electrified; they do not disturb the wildlife"*①
- *"competition with ungulates (e.g. gemsbok) over pasture"*①
- *"we made holes in the fence where the old game tracks are so that the wildlife can pass"*①
- *"we do not have a game fence so wildlife can migrate, hunting farms usually have a dense fence which is a big problem for wildlife during droughts"*①
- *"I do not think that the cattle farming disturbs wildlife"*②
- *"for doing business there must be a high closed fence around the farm, as we also buy wildlife species which are not common in the area"*②
- *"there are species like kudu and eland which do not worry about the high fence they can jump over it; other species which do not jump stay inside"*②
- *"I think it does not make a big difference if there is electricity on the fence; but without electricity it is easier to cross"*②
- *"if the animals are chased they can run into the fence but I think they learn to avoid the fence"*②
- *"we have like a park and thus no fences inside; the animals are moving with the rainfall and eat all the grasses"*②

- *"in 2016 many wildlife starved on my farm (mainly grassers), although I fed them; browsers did better"*③
- *"kudu is not a grazer and thus no competitor to cattle"*③
- *"prices for wildlife are low, since a lot of wildlife is on the market due to drought"*③
- *"wildlife is avoiding cattle, as there is competition for forage"*③
- *"fences are pretty much game prove but when wildlife wants to pass, they find a way"*③
- *"predators are not stopped at al by fences including electric fence"*③
- *"warthog is digging under the fences, so that other wildlife can pass"*③
- *"the larger fenced pastures are, the more wildlife friendly they are"*③
- *"I see no need for electric fences, we have game prove fence (2.4 m with at least 16 wires)"*③
- *"some farmers use electric fence, but then the fenced areas are small"*③
- *"cattle does not disturb wildlife necessarily, they can sometimes be found together at a waterhole"*④
- *"we do not use electric fences, thus it is easy for the wildlife to cross the fences"*④
- *"they cannot leave the farm because of the high game fence (2.3 m)"*④
- *"there is no competition because I like farming of cattle and wildlife"*④
- *"when there is no money with cattle farming we can make money with wildlife"*④
- *"rain and grasses determent the direction of the animals going"*⑤
- *"a lot of game died and cattle are not that plenty anymore because of drought"*⑤
- *"the hunting business depends on the rain; this year is a drought year so the game is not that plenty"*⑤
- *"we use just normal cattle fences, no electricity, they are about 5 feet high"*⑤
- *"normally I use 6 wires for fencing without electricity"*⑥
- *"high fences would affect the wildlife movement but we have low fences"*⑥
- *"wildlife farms do use high fences to keep the wildlife in"*⑥
- *"some wildlife species jump over, others go underneath the fence"*⑥
- *"it's an open system with the neighbors, we rely on each other to do it in a sustainable way"*⑥
- *"it is hard to farm with droughts and all these things"*⑥
- *"due to the droughts there are only short-term grasses that's not good"*⑥
- *"we have lots of wildlife and there is definitely a competition with cattle during drought"*⑥
- *"this year the wildlife is moving away, as there is not much grazing for them; now their condition is still all right but later in the year they will have a problem"*⑥
- *"it's the worst situation now what I have seen in my lifetime, the biggest problem now is the drought"*⑥
- *"now with the drought the leaves are falling, which causes problems for the browsers"*⑥
- *"the loss on the cowherd is quite large during droughts"*⑦
- *"I think livestock and game farming is in trouble due to drought"*⑦
- *"compared to wildlife, livestock is quite easy to move from one farm to another"*⑦
- *"wildlife is starving during droughts on game farms, as they cannot get out"*⑦
- *"I think if the NP would keep their fences in good condition we would have less problems"*⑦
- *"the cattle does not disturb the wildlife at all"*⑦
- *"there are species like oryx and zebra which also eat grass so they are on competition with cattle particular when there is a lack of grasses"*⑦
- *"I assume that the wildlife feels save when the cattle is there"*⑦
- *"the wildlife lives freely, they can come and go as they like, they just cross the fence to the neighbor's farm"*⑦
- *"we use normal cattle fences without electricity"*⑧
- *"you find cattle and wildlife altogether; I don't think they bother each other, they are used to it"*⑧
- *"zebra and kudu are warning the cattle when hyena or lion is on the way"*⑧
- *"now in the dry season I feed the wildlife but I think before the next rain season some of them will die"*⑧
- *"I can't feed them all and at this stage nobody will buy wildlife"*⑧
- *"particular in arid areas there is competition with zebras and oryx for grasses"*⑧
- *"many people survive through wildlife and tourism, but they also have a lot of problems"*⑧
- *"if you look at any game farm during drought there is no grass, because they cannot do rotational grazing with game"*⑨
- *"you need stable 3 month of rain a year to be able to do game farming"*⑨
- *"cattle you can sell but game you have to shoot out"*⑨
- *"single farms are too small for effective wildlife management"*⑨
- *"the kudu population has increased due to farming because of more water and the bush-encroachment"*⑨
- *"cattle has no real impact on the wildlife but the other way around; when there are too many oryx and zebras they are competing with the cattle because they are all grazers"*⑨
- *"our farm is an open system, the wildlife comes and goes; we have no electric fences for cattle farming"*⑨
- *"we use electric fence for small stock but not for cattle; we use 6 wire livestock fence 1.25 m high to keep the cows in"*⑩
- *"the cattle farming does not affect the wildlife; wildlife can pass fences"*⑩
- *"the wildlife is not scared away by the livestock but they usually do not come the same time as the cows because the cows you find during the hottest time of the day at the water hole; the game comes earlier or later on but it is not a rare thing to see oryx together with cows"*⑩
- *"in times of shortage of grazing big numbers of oryx and zebra come to your farm and finish all the pasture; there is more than competition"*⑩
- *"in livestock farming it is impossible to quickly adapt; if it is not going to rain everybody wants to get rid of cattle so the market is flooded and the prices go down"*⑩
- *"there is no grass cover on the farm anywhere even where we debushed"*⑩
- *"we have had 7 years of drought during the last 30 years, that's bad and then there is a problem with competition"*⑪
- *"we have a lot of wildlife on the farm but they can also go to the neighbors by jumping fences"*⑪
- *"I have just a normal cattle fence without electricity it is just too big, the border is 36 km"*⑪
- *"the wildlife doesn't mind being in the same camp with the cattle"*⑪
- *"when it is dry competition with grazers (oryx and zebra) is a big problem"*⑪
- *"cattle grazing disturbs the wildlife on the pasture"*⑫

- *"kudus are not so effected by cattle but grazers like oryx and eland they prefer not to stay in the same area; there is obviously a competition over grasses"*⑫
- *"due to the high fence around the fence wildlife cannot go out or come in, on jumping animals like kudu and eland it has no effect although big kudu bulls get stuck in the fence many times"*⑫
- *"wildlife is better adapted to drought compared to cattle (wildlife can survive with less food), but during drought wildlife is more difficult to manage compared to cattle, which can be kept in a kraal"*⑫
- *"if there is enough grass I don't have a problem with the grazers but in a year like this I do have a problem with them"*⑫
- *"I use normal cattle fences 5-7 wires"*⑬
- *"they have no impact on game movement; they go underneath or jump over"*⑬
- *"you have got a lot of maintenance on the fences because of the wildlife but it does not prohibit them to move unless it is a high game fence"*⑬
- *"oryx tend to move out when the cattle is in the camp, they move to the camps where there is no cattle for grazing"*⑬
- *"oryx is in direct competition for grass with cattle and a problem in pasture management; so you must control numbers"*⑬
- *"now the animal prices went down extremely due to the oversupply and the costs for maize went up extremely, diesel prices are hiking and we do not know for how long we need to do that"*⑬
- *"usually there is no competition with cattle but in this extremely dry year the oryx are in competition and then you try to reduce their numbers either by game capturing or selective hunting"*⑬

Serengeti Region

Stakeholder functions and relations

- *"60 % income from livestock farming (40 % from crop growing)"*①
- *"we prefer a high number of animals and grazing"*①
- *"we rarely slaughter cattle for meet"*①
- *"for us cattle is important for instance as bride price or to buy land"*①
- *"cattle also functions like a bank account"*①
- *"we like to invest in cattle and when we need money we sell some"*①
- *"cattle quantity is connected with prestige"*①
- *"there is no official hunting, as we are not allowed to kill wildlife"*①
- *"we have a friendly partnership with TANAPA"*①
- *"50 % income from livestock farming (50 % from crop growing)"*②
- *"we like to invest in cattle because it acts like a bank account"*②
- *"cattle also functions as health insurance"*②
- *"I need cattle to pay the education and bride for my children"*②
- *"previously we had a good friendship with the national park but"*②
- *"30 % income from livestock farming (70 % from crop growing)"*③
- *"cattle can help us when we have problems"*③
- *"we use cattle to cultivate our fields"*③
- *"we use cattle to pay the bride price"*③
- *"for us livestock keeping is our culture"*③
- *"40 % income from livestock farming (60 % from crop growing)"*④
- *"we livestock keepers are just looking after our cattle; we don't care about the environment"*④
- *"we use the cattle to pay bride price and education of our children"*④
- *"we use cattle to finance the treatment of health issues and to buy food during droughts"*④
- *"cattle is 10 times as valuable as sheep and goat, thus we prefer to keep cattle"*④
- *"livestock farming is our life"*④
- *"conservationist"*⑤
- *"a Maasai without cattle has no value in the society; it is a prestige when you own a big number of cattle"*⑤
- *"Maasai believe that all the cattle belong to them"*⑤
- *"for Maasai pastoralists livestock keeping is part of their life"*⑤
- *"pastoralists prefer large numbers of livestock, particularly cattle to sustain their big families, comprising several wives"*⑤
- *"conservationist"*⑥
- *"we are working together with the protected areas and privately organized conservation"*⑦
- *"we get assistance from Grumeti Fund"*⑦
- *"the area we are working in is owned to 100 % by the Government (Ikorongo Game Reserve, Grumeti Game Reserve and Ikona WMA)"*⑧
- *"we as investor support the government to conserve the wildlife protecting these areas, we work hand in hand"*⑧
- *"40 % income from livestock farming (60 % from other jobs)"*⑨
- *"we Maasai do not eat wildlife so we do not hunt, but other communities do a lot of poaching"*⑨
- *"cattle is very important for our culture (e.g. for marriage)"*⑨
- *"without cattle we are not recognized and respected in our community"*⑨
- *"cattle is also an important source of income; livestock is sold to solve problems"*⑨
- *"conservationist"*⑩

Major human-wildlife conflict associated with cattle farming

Restrictions of cattle farming through conservation

- *"the border between NP and grazing land is the river; formally it was a little bit behind; cattle can cross while drinking"*①
- *"500 meters adjacent to the national park is set aside for grazing of livestock"*①
- *"livestock farmers with large herds come from other areas and invade our village grazing land"*①
- *"the government should help us to expand the grazing area"*①
- *"there is not enough grass and the grazing area is decreasing"*①

- *"we take resources from the national park because of the drought"*①
- *"the major conflict is that we graze inside the national park during drought, although prohibited"*①
- *"the wildlife in our country is a prestige, but the government wants to separate us"*①
- *"we asked the rangers for permission to bring the cattle in the national park during the drought when there is no grass left outside but they refused"*①
- *"illegally hunting is taking place and game meat is sold as a source of income"*①
- *"all wildlife is protected by the rangers and we are not allowed to hunt"*②
- *"there are some poachers in the neighbour village"*②
- *"we all depend on the grazing area next to the national park, which is decreasing"*②
- *"previously we had a good friendship with the national park, but in our days the situation is different because we don't receive any services for the village anymore"*②
- *"the government should provide a sufficient area for grazing livestock to solve our problem"*②
- *"an area for grazing cattle within the national park would be good"*②
- *"the major conflict here is that we graze the cattle inside the national park, although this is illegally"*②
- *"while drinking my cattle accidently crossed the river into the national park; I was caught by the rangers and fined"*②
- *"in the past we were moving from one area to another for grazing but nowadays we have permanent houses and appreciate the related benefits"*②
- *"the government should say which land is for grazing and which for agriculture"*②
- *"there is not enough grazing land anymore; we can only go to the grazing areas, which are reserved by the government"*③
- *"there is no chance to find a free piece of land like in the past"*③
- *"you even find conflicts due to limited grazing land between pastoralists themselves"*③
- *"livestock can also cause conflicts with crop farmers in the area"*③
- *"in the past we could move freely, but now due to increasing human population we cannot migrate easily because every piece of land is owned by someone"*③
- *"it is difficult to move for grazing, as I have a permanent house now; that's why cattle is dying here"*③
- *"the NP shifted the border and took a piece of village land; we are fined when the rangers find us grazing on that land"*③
- *"some farmers graze their livestock illegally inside the national park during the night"*③
- *"the rangers should increase the communication with us"*③
- *"more information should be provided to villagers about the importance of wildlife"*③
- *"it is common that people illegally cut fire wood inside the national park"*③
- *"we do not have a hunting system and registered hunters in the villages"*③
- *"the government is afraid about poaching"*③
- *"we do not have hunters and a hunting system; nobody is selling wild meat here"*④
- *"in the 500 m buffer zone it is not allowed to do agriculture or to build houses, but grazing of cattle is tolerated"*④
- *"other people sometimes graze the cattle illegally inside the park"*④
- *"my cattle has never been to the national park, that's why I told you that there are animals which are suffering from hunger at my home; I feel shame"*④
- *"there is a lack of grazing areas nowadays; the government should allow us to use the national park to graze our cattle"*④
- *"the grazing area is decreasing"*④
- *"increasing fragmentation of rangelands is a serious issue, as mobility is very crucial for traditional pastoralism"*⑤
- *"most of the land has been taken by conservation, crop farming and so on"*⑤
- *"I personally would support the idea of livestock grazing with limitation in pas during droughts"*⑤
- *"the government is afraid that when they allow the livestock keepers they will think it is their own"*⑤
- *"if we allow all the cattle to graze in the protected areas they will destroy the wildlife habitat"*⑤
- *"the areas which seem to be suitable for grazing are inside the protected areas but that is against the law"*⑤
- *"but ones livestock farmers don't have an alternative (during drought) they come strategically to live very close to the protected areas and during the night they graze the cattle inside"*⑤
- *"the cattle not necessarily belongs to farmers from that area"*⑤
- *"this is raising many conflicts between conservation and livestock keeping"*⑤
- *"Tanzania is blamed that protected areas were established on land with potential for agriculture"*⑤
- *"there is a competition; the availability of forage depends on the rain, which is not stable nowadays"*⑤
- *"cattle found in the NP can be arrested and sold… this happened to Kenyan cattle, which came to Tanzania; Kenya then did the same with the Tanzanian cattle (Maasai don't even know the border)"*⑤
- *"there is a lot of pressure along the boundary of the protected areas"*⑤
- *"outside Serengeti NP the situation was not so good for conservation, but now the government tries to establish WMAs"*⑤
- *"there is no sharing of benefits from conservation and the damages make farmers angry"*⑤
- *"local communities in the area should benefit more from the revenues of the pas"*⑤
- *"this could enhance the positive feeling of the presence of the national park; the sustainability of these Pas depends on the perception of the communities"*⑤
- *"the solution is to continue to educate the livestock keepers (make them aware about conservation) because tradition has a very big role in the behavior of the people"*⑤
- *"the government introduced community conservation projects around the national parks"*⑤
- *"we try to involve the communities in the conservation"*⑤
- *"these protected areas, they are for the matter of raising the country's economy"*⑤
- *"WMAs have potential because they have a budget which they share in the communities. There are lots of investors which can bring money into the region"*⑤
- "Wildlife Management Areas (WMAs) are on communal land with the potential for conservation"⑤
- *"there is a 500 m buffer zone by law, which is not implemented… you find settlement up to zero distance"*⑤
- *"there is grazing and sometimes settlement in open areas because there are not much control activities"*⑤
- *"the big challenge for the sustainability of the protected areas is cattle and human population growth"*⑤
- *"inside the national park only photographic tourism is allowed"*⑤
- *"we have local hunting and tourist hunting; local hunting is forbidden since two years"*⑤

- • "poaching is very common in the region; traditional values are attached this activities"⑤
- "we have the hunting blocks which are owned by investors and they put much effort into conservation"⑤
- "the area is very friendly for wildlife; thus animals come very close to villages, which increases interaction and conflict"⑤
- "pressure through human population growth causes land conflicts even in WMAs, where land use plans are in place"⑥
- "proper land use plans are not implemented"⑥
- "benefits of WMAs are at communal level"⑥
- "issues are common where community land borders to protected areas, initially used by wildlife"⑥
- "the mayor issues here is how to manage the little land for all the competing needs that there are"⑥
- "when you want to exclude grazing from a certain area you would need someone to patrol there"⑥
- "the government plan is to extend the Serengeti up to the Lake Victoria and wants to shift the people, living between Lake and national park to other areas"⑥
- "survival of wildlife in the Serengeti depends on water from the Lake Victoria, but human settlements block the corridor"⑥
- "Lake Victoria is very close, wildlife must have used the land in the past, so it is logical to protect the area and allow for wildlife movement between Serengeti National Park and Lake Victoria"⑥
- "the people became a village certificate although the land was set aside for conservation"⑥
- "land for conservation shall be set aside close to existing protected areas but villagers did not accept the WMA because they use the land for grazing and refused to change that use to wildlife conservation, as they would loose grazing land"⑦
- "one challenge here is the overstocking by farmers, that's why we have a problem with livestock keepers, which take their cattle to protected areas; although they are not allowed"⑦
- "via WMAs we want the local people to adapt ideas of wildlife conservation; the incomes generated in WMAs are going directly to the villages"⑦
- "we need to introduce land use plans in the villages to support the wildlife"⑦
- "there need to be specific grazing areas and land for conservation"⑦
- "we used to offer hunting licenses for local people but local hunting is not conducted nowadays"⑦
- "when we leave these areas without disturbance, wildlife will come back and we can continue hunting"⑦
- "since Grumeti Fund is operating in the area, residential hunting is prohibited; we pay the local authorities to not distribute licenses for residential hunting; thus, wildlife numbers are increasing tremendously since"⑧
- "when we find people hunting or harm wildlife we arrest them because the wildlife belongs to the government weather they are inside or outside protected areas"⑧
- "we have never had a situation that the wildlife numbers were so high that they need to be shot down"⑧
- "here in Tanzania the nature controls itself (carnivores control herbivores)"⑧
- "wildlife numbers will not grow above the carrying capacities of the protected areas; they leave the protected areas but we do a lot of effort to minimize the impact"⑧
- "most villages here have village land use plans but they are not enforced; it is most important to enforce them"⑧
- "Singita Grumeti Fund has a department which gives education to farmers"⑧
- "we rent 3 protected areas from the government and communities"⑧
- "nobody is allowed to enter the protected areas without our permission; we arrest the people no matter if they were hunting or not"⑧
- "the areas we rent from the government and communities to work inside exclusively"⑧
- "we catch farmers grazing in protected areas and the government fines them; but they get the cattle back and continue"⑧
- "we are worried that cattle cause lots of environmental destruction in the protected areas"⑧
- "since the pastoralists do not have sufficient pasture anymore they go illegally into the pas"⑨
- "once pastoralists get caught in the NP, they get beaten and a lot of human right violation is taking place"⑨
- "the traditional pastoral land should remain the same (government should stay away)"⑨
- "the government is only interested in money and not in wildlife; there is a need for benefit sharing"⑨
- "the government wants to centralize income from wildlife, and not the communities to directly access the resources"⑨
- "pastoralists don't have negative attitudes towards wildlife but the government has negative attitude towards pastoralists"⑨
- "there is no partnership between people, which are keeping animals outside and the government, that is keeping them inside the protected areas"⑨
- "conflict between wildlife and livestock because the government is creating boundaries and refuses to acknowledge that coexistence of both is possible"⑨
- "the government is burning Maasai houses frequently, which is inhuman; sometimes this is done without reason and for self-interest of individuals within the government"⑨
- "Maasai used to graze transboundary between Tanzania and Kenya for many years but now livestock is confiscated"⑨
- "the communities should be involved into conservation (community based wildlife management)"⑨
- "the grazing land is decreasing; the government allows crop farming everywhere and the livestock has to stay in a very small area, which end up in overgrazing"⑨
- "grazing in buffer zones is prohibited, but there is also a lot of corruption taking place"⑨
- "the problem starts when we are accessing the grazing areas; many boundaries are not clear"⑨
- "the government does not respect the boundaries; the protected areas are increasing continuously, which affects the size of the grazing area and the mobility of the people"⑨
- "most conflicts are due to the establishment of protected areas, which is about 30 % of the country"⑨
- "Maasai used to life in Serengeti, Tarangire and Manyara but now they are not allowed to go inside"⑨
- "the government is increasing buffer zones and other categories of pas including WMAs where access to grazing land becomes increasingly difficult; that is where the conflict comes from"⑨
- "there are several conflicts between villages and protected areas because the government has the power; they just remove people from areas"⑨
- "government allows crop farming everywhere and the livestock has to stay in very small areas, leading to overgrazing"⑨
- "it is very important to have land use plans which recognize all activities within a certain area"⑨
- "the solution would be participatory land use planning that involves us pastoralists"⑨
- "I do not know if the modern concepts of carrying capacity are suitable for our mobile systems"⑨
- "poaching of wildlife for bush meat has decreased and is not a big issue anymore"⑩

- *"there are strong wildlife protection units and poaching has become a risky business"*⑩
- *"we depend on the information from the villagers (game-scouts) about poachers"*⑩
- *"the government owns hunting blocks; an investor pays all hunting fees but uses wildlife for eco-tourism only"*⑩
- *"the most important thing is to change the attitude of the farmers in means of sustainable use of resources and sharing with wildlife"*⑩
- *"the idea of the WMAs is that local people benefit from wildlife and thus support conservation, which is not the case; they do not like the existence of the WMAs mostly because of HWC and losses through wildlife"*⑩
- *"70 % of revenues from tourism go to the WMA (half of it for the villagers, half of it for WMA operations)"*⑩
- *"cooperation between livestock farmers and conservationists is necessary to ensure coexistence"*⑩
- *"they expect reimbursement for the financial losses through not using the resources"*⑩
- *"some communities want to establish WMAs but the government does not want to give the power to the communities"*⑩
- *"the government rather wants to vacate all people from the area and get all revenues from tourism"*⑩
- *"conservationists should care more about the people's needs (they do not care about people killed by wildlife but only about wildlife killed by people)"*⑩
- *"some of the member villages would like to deregister from WMA because they get not enough benefits"*⑩
- *"farmers should be allowed to bring cattle into the pas, but this has to be controlled; there should be zones which are not used and others which can be used for livestock farming"*⑩
- *"people set aside land for conservation, which is not easy for them, since it is needed for pastoralism too"*⑩

Predation of cattle by large carnivores

- *"hyenas predate our livestock"*①
- *"hyenas are a problem, as they pass during the night; usually no other large carnivore comes from the NP to the village land"*②
- *"the hyenas come from the national park to the village land and kill our livestock"*③
- *"when cattle get accidently lost in the bush they can be killed by hyenas during the night"*③
- *"the only predator which disturbs us is the hyena; the hyenas come to kill our goats every day"*④
- *"here predation is not very high experienced; there is some conflict with lions and also with hyenas"*⑤
- *"when farmers graze the cattle inside the protected areas is when the carnivores get access to the cattle"*⑤
- *"in the Serengeti lions sometimes raid cattle inside the bomas"*⑤
- *"lions, hyenas and leopards can cause predation of livestock, but this is not a big issue in our area"*⑥
- *"the challenge with the lions is not as big as with the elephants"*⑦
- *"there is livestock predation in particular by hyenas it is a big problem"*⑦
- *"conflicts with lions have increased"*⑧
- *"livestock is threatened by predators during the night; when lions kill cattle there is no problem as we understand that"*⑨
- *"livestock predation is a common HWC"*⑩

Damage by naturally occurring ungulates

- *"when the elephants come from the NP to the village land we make noise, but sometimes they refuse to go and destroy our crops; the government should stop the elephants from coming to our land"*①
- *"wildlife destroys our buildings, crops and livestock"*②
- *"when animals like the elephant come to graze on our crops they are not paying us, but when our animals go to the park for grazing then we have to pay fines"*②
- *"I think a fence around the NP is needed to prevent the wildlife to come to village land"*②
- *"livestock is just grazing but the elephants are destructive"*③
- *"elephants come from the NP during harvest season and destroy our crops; we don't have a strategy"*③
- *"we have a serious problem with the elephants, which destroy our crops and break trees"*④
- *"we don't have a strategy against elephants because this is a new situation for us"*④
- *"we have many conflicts in this area with the elephants"*⑤
- *"the number of elephants in the area has increased in recent years"*⑤
- *"there is no compensation but sometimes consolation which is just a small amount from the government"*⑤
- *"it is very difficult to maintain fences over time and it is a lot of input, which is a challenge"*⑥
- *"problems with elephants have increased in the region"*⑦
- *"farmers can apply for consolation; the amount paid is not sufficient and does not come on time"*⑦
- *"as the amount we are paying them is very little the farmers are not satisfied"*⑦
- *"farmers close to protected areas get a smaller amount than ones which live far away, because we do not want that people conduct their business near protected areas"*⑦
- *"wildlife numbers have increased and they leave the protected areas into village land and destroy crops"*⑧
- *"conflicts with elephants have increased"*⑧
- *"the acceptance of wildlife by farmers decreases with the shift from livestock to crop farming"*⑨
- *"we have developed a set of 4 tools (flashlight, blow horn, chili powder bombs, roman candles) to chase away wildlife from village land to mitigate HWC"*⑩
- *"these tools are purchased by 50 % through funding and 50 % by money from the villagers"*⑩
- *"we train teams of volunteers from the villages how to protect their farms and give them the toolkits"*⑩
- *"we had a trail with chili fences which worked and we plan to increase the measure"*⑩

Practices to mitigate predation of cattle by large carnivores

- *"goat sheep and calves are inside a stable to protect them from hyenas during the night"*①
- *"adult cattle is protected through bomas built from thorny branches"*①
- *"I like cattle with long horns, as they can fight hyenas"*①
- *"dogs act as livestock guards during the night"*①
- *"we use a torch to chase the hyenas away"*①
- *"when we see a lion we can report that to the rangers, which come to chase it away"*①
- *"during the night the cattle stays inside a boma from branches with thorns"*②
- *"smaller calves, goats and sheep sleep inside a stable"*②

- *"we use many dogs, which act as guards during the night"*②
- *"when they bark we go out with a torch and chase the hyenas away"*②
- *"during night cattle is kept in a boma, which make it difficult for the hyenas and other predators to enter"*③
- *"we also have dogs"*③
- *"we go out with the torch and chase the hyena away by using the light"*③
- *"long horns can help the cattle to defend their calves against predators like hyenas"*③
- *"calves have a separate place inside the boma, where they are more protected than the adult cattle"*③
- *"during night the cattle is inside the boma"*④
- *"calves are also inside the boma but they are separated from the adults"*④
- *"we use branches with thorns, since wire is expensive; we put enough thorns and have never experienced problems"*④
- *"horns of cattle are only decoration; they do not help them to defend themselves from predators"*④
- *"we have 3 dogs to keep the cattle save during night"*④
- *"the cattle goes with a person (herder) who looks after them during day"*④
- *"we use strong bomas during night and herders looking after livestock during day"*⑤
- *"the strength of the bomas are criteria to receive benefits in form of social projects"*⑤
- *"bomas (thorns and wire), stable, solar panels and security lights and occasionally electric fences"*⑤
- *"increased awareness in the villages and protection measures are supposed to reduce cattle predation"*⑤
- *"there is consolation for predation of livestock, but it is very difficult to get"*⑤
- *"a piece of land close to the settlement for weak and small cattle; only strong cattle moves far distances"*⑤
- *"the list of dangerous animals comprises: black rhino, spotted hyena, hippopotamus, nil crocodile, buffalo, lion and African elephant; only damages through these can be paid for"*⑥
- *"farmers use spotlights and solar lights to scare of predators"*⑥
- *"bomas are not barriers which avoid predators to access livestock; there is potential to increase their affectivity"*⑥
- *"sometimes people poison and lay snares, but the farmers would not tell you"*⑥
- *"Maasai kill lion as revenge for livestock losses through predation by hyenas"*⑦
- *"we form community groups in the villages and support them with the mitigation of HWC"*⑦
- *"compensation is paid but it can last several years until the farmers receive the money"*⑦
- *"farmers use light during night in the livestock enclosures, flash lights and dogs"*⑧
- *"we support them in chasing carnivores away"*⑧
- *"farmers do not receive compensation, only consolation; to receive consolation farmers have to report to local government officials and fill out forms"*⑧
- *"cattle is kept fenced only during night for protection against carnivores; traditionally thorny branches but there are new ideas like iron fences"*⑨
- *"one measure is to build strong bomas; socalled 'living wall', which is a combination of wires and trees"*⑩
- *"adult cattle herders"*⑩
- *"we support farmers to find livestock when they lose it"*⑩
- *"alarm kit as early warning system; strong lights are mounted around the boma with a wide trigger alarm"*⑩
- *"flashlights are very effective to chase away predators"*⑩
- *"human presence is enough to scare away any animal"*⑩
- *"noise from the blow horn works for lions"*⑩
- *"we rather believe in preventive measures to change attitudes instead of compensation"*⑩

Practices to assure ecological sustainability of cattle farming

- *"we make charcoal and fire wood to gain income, necessary to buy food for our survival"*①
- *"I graze also on the neighbours land; we help each other during droughts"*①
- *"grazing of cattle opposes the environmental conservation"*①
- *"we do not manage the grazing area sustainably because of politician uncertainty"*①
- *"when the pasture is finished and the animals start to suffer and even die, cattle can cause erosion but we have to continue grazing"*①
- *"we use a common grazing area next to the national park, which is given by the government"*①
- *"we need to reduce the number of cattle, but the people need time to change their habits"*①
- *"as my own land is insufficient, I also graze my stock on the neighbours land"*②
- *"in the past we were keeping a land as a reserve for grazing during the dry season"*②
- *"grazing of cattle is not environmentally friendly as it causes soil erosion; there is no other option to support the livestock during draughts"*②
- *"most farmers here have between 30 and 50 cattle"*②
- *"reducing the number of cattle, as demanded by the government, means inviting poverty to our families"*②
- *"I want to increase the amount of cattle"*②
- *"when there is no drought we graze the livestock close to the house, but when there are no grazes left we move to other areas in order to find pasture"*③
- *"the government is telling us to reduce the amount of cattle according to the available land"*③
- *"for the sustainability of the grazing system we should reduce the number of cattle or improve the management"*③
- *"it is better to sell some cattle before the drought instead of losing them"*③
- *"people with large herds need to reduce the amount of cattle and improve the livestock farming"*③
- *"when a big herd of cattle is grazing on a piece of land like mine, the grasses can be finished in one day"*③
- *"grazing cattle and conservation have nothing in common, as large herds of cattle can easily destroy the environment"*③
- *"we will never stop keeping cattle but need to look more at the issue of conservation"*④
- *"some people have large amounts of cattle which can finish the available grasses very fast"*④
- *"on the search for grasses we move the cattle from one place to another"*④
- *"we graze until we see that the grasses are finished or not enough, then we shift the cattle to a place with better pasture"*④
- *"we come back after some time, when the grasses have grown again"*④
- *"we need to reduce the number of cattle because we do not have enough grazing land"*④

- *"we should be reminded about conservation of the environment"*④
- "we remove trees and bushes from the rangeland because they germinate themselves and disturb farming*; these* bushes are a result of livestock keeping"④
- "rangers frequently burn the land inside the national park and thus harm the trees"④
- *"we* farmers are not burning the grassland"④
- "there are trees which are not affected by fire; I don't like them on my land but I failed to remove them"④
- *"pastoralists move with the rain and the availability of water; the availability of grass is not necessarily a problem"*⑤
- *"the individual pastoralists have small areas where they graze their stock, but the main grazing areas are common"*⑤
- *"Maasai in nowadays are changing and try to commercialize livestock keeping"*⑤
- *"people occupy now more potential rangelands"*⑤
- *"in former times the population of people was not very high and many regions were not occupied by people; pastoralists were moving according to rain- and dry seasons"*⑤
- *"cattle was shifted from places with high pressure to places with low pressure, where they could find grasses and water"*⑤
- *"changes are happening like the establishment of permanent settlements and social services"*⑤
- *"we have permanent houses nowadays; so moving means just shifting cattle temporally to another area"*⑤
- *"pastoralists like to have permanent houses; they started crop farming as an alternative way of life"*⑤
- *"the land is not as free as it used to be; you find human population now in several areas, which causes conflict"*⑤
- *"the land used to be communal owned, but now you find that someone says that's my own farming area"*⑤
- *"bush encroachment is the result of very intensive livestock farming"*⑤
- "we don't have facilities to maybe bring hay; for us all these techniques are not suitable, because we do not invest much"⑤
- *"traditional grazing management does not include the collection of grasses for seasons of shortage, but now people are starting to collect grasses and crop residues for the dry season"*⑤
- "pastoralists have areas which they only use during dry seasons and not during rainy seasons"⑤
- *"in the Serengeti many elephants always clear the bushes and fall the trees; so regeneration becomes very difficult"*⑤
- *"the people need to better take care of the land themselves so that they leave pasture for dry season"*⑥
- "fire is used in various protected areas to manage grasses, because fires are historically part of the system"⑥
- *"overgrazing through unsustainable land use is an issue"*⑥
- *"there is a need for management practices which help to build resilience to withstand droughts"*⑥
- *"local people want to enjoy a semi urban live stile and still keep livestock"*⑥
- *"a limitation of livestock numbers is required; they have to reduce cattle"*⑦
- *"farmers cut trees in the areas to improve pasture and to produce charcoal, which is a problem"*⑦
- *"fires are frequently used as management tool inside protected areas"*⑦
- *"grasses are reduced through heavy grazing and Acacia drepanalobium trees grow easily, as during dry season there is no fuel to burn the tree seedlings"*⑧
- *"there is a lot of bush encroachment through grazing of cattle outside the pas, which reduces the available grazing land and brings the cattle into the pas"*⑧
- *"we do controlled burning (firebreaks in order to protect sensitive habitats and infrastructure)"*⑧
- *"we also do cool-burning to encourage forage for herbivores and suppress unwanted fires"*⑧
- *"there are a lot of cattle in the area, but most comes from other areas as they know that there are sometimes chances to graze in this areas and eventually inside the protected areas"*⑧
- *"they shouldn't keep big numbers of cattle just for prestige and eventually have no land to graze them"*⑧
- *"they need to make sure that they keep livestock numbers according to the amount of land that they have, otherwise the conflict with livestock inside protected areas will increase"*⑧
- *"there is the habit of welcoming livestock farmers from other regions although they know that they do not have sufficient pasture in the area; as a result they are forced to graze their livestock inside the protected areas"*⑧
- *"pastoralists used to keep as many cattle as they can and are still doing that in some places"*⑨
- *"this is to reduce risk (the higher the number of livestock, the more of them will remain after a drought)"*⑨
- *"pastoralism is based on movement of livestock, according to availability of pasture, availability of water and diseases"*⑨
- *"grazing land is a common property of the community members"*⑨
- *"overgrazing is happening because the pastoralists are forced to stay at one place nowadays"*⑨
- *"overgrazing would not occur when pastoralists would practice their traditional movement of livestock, traditional management of natural resources"*⑨
- *"farmers used to burn to suppress bush encroachment but it is prohibited now"*⑨
- *"farmers try to pull the trees out but they are growing too fast"*⑨
- *"nothing is being done to eradicate the invasive species"*⑨
- *"bush encroachment is also common within WMAs through encroachment of outsiders"*⑩
- *"we have not seen many fires on the village land"*⑩
- *"think soil erosion is a bigger problem than bush encroachment"*⑩
- *"grazing is allowed in some parts of the WMAs, while all human activities are prohibited in others parts"*⑩
- *"even during serious drought last year, we had sufficient pasture within the WMAs"*⑩
- *"we have enough resources in the WMAs for livestock and wildlife as long as it is controlled"*⑩
- *"another option would be rotational grazing and control of livestock numbers"*⑩
- *"villagers have to defend their grazing land against encroachment by pastoralist from the outside"*⑩
- *"we have growing numbers of humans and livestock while rangeland is decreasing through overgrazing and drought"*⑩

Impact of livestock farming on wildlife presence and activity

- *"we do not use any fences but human herders"*①
- *" wildlife don't cross the border because they don't like disturbance through human activity"*①
- *"wildlife stays within the national park because it does not like disturbance through human activities"*①
- *"during the day the wildlife hides somewhere"*①
- *"there is no need to chase wildlife away; they stay away when they see humans"*①
- *"when we enter the park, cattle and wildlife can graze next to each other"*①

- *"the disturbance of wildlife through the grazing of cattle is species specific"*①
- *"wildlife mainly leaves the NP when they do not find sufficient pasture, which happens very rarely"*①
- *"cattle is grazed and controlled by humans (herders)"*②
- *"the grazing of cattle does not affect the wild animals"*②
- *"the behaviour of wildlife and cattle is similar"*②
- *"the movement of wildlife is not restricted; it can go where ever it wants"*②
- *"cattle do not disturb wildlife, as wildlife is inside the NP and cattle are grazed outside"*③
- *"I or my children herd the cattle during day; we do not have fences"*③
- *"there is no competition because the wildlife is in the NP and the cattle outside"*③
- *"hyenas come usually only during night, as they fear humans"*④
- *"wildlife and cattle are separated, there is no interference"*④
- *"wildlife has its space inside the NP, if it would be a protected area here, they could stay here; but that is not the case so the wildlife is not here"*④
- *"there are animals, which are not so much afraid; there are small animals like antelopes which come here so we are grazing together with them"*④
- *"even the large mammals (e.g. zebra, wildebeest, antelopes and gazelles) used to come here, but since the population of people has increased in the area, they are not coming anymore"*④
- *"we do not have fences because they are expensive"*④
- "our policy does not allow fencing of protected areas"⑤
- *"the land use outside and inside the WMA is very different, because of highly populated villages with a big number of cattle, highly grazed outside"*⑤
- *"cattle grazing can influence the wildlife species to be in that area (prefer bush or open land)"*⑤
- *"the number of livestock is becoming very high"*⑤
- *"farmers are being told to reduce their amount of livestock but currently there is no market"*⑤
- *"each village should have a limited cattle population"*⑤
- *"the government tries to reduce the amount of cattle by developing markets for cattle"*⑤
- *"a big number of cattle can easily graze an area to erosion, like in this area where many people live"*⑤
- *"through transformation of land, wildlife can't access the lake, which is an issue"*⑥
- *"here, livestock and wildlife do not graze together like in the Ngorongoro conservation area"*⑦
- *"where the cattle is, there is no wildlife, they stay away"*⑦
- *"some species like e.g. elephant and wildebeest are not so sensitive"*⑦
- *"people have invaded into the open areas and use the former hunting blocks for things like settlement, grazing and agriculture, thus wildlife is scared and avoids the area and we cannot offer hunting licenses"*⑦
- *"there are no fences used in the area neither by farmers nor conservationists"*⑦
- *"in this area there are no fences we do not have such a policy in TZ. It is not possible to construct fences without special permission from the government. Fences interfere with the running of the ecosystem"*⑧
- *"the disturbance of wildlife through cattle grazing is due to human presence (herders)"*⑧
- *"each species has a tolerance distance; when people come beyond this distance they run away"*⑧
- *"particular during migration there is competition for resources when the wildlife grazes on village land"*⑧
- *"the main issue is competition for resources"*⑨
- *"pastoralists do not disturb wildlife and wildlife is not afraid of Maasai herders"*⑨
- *"there is a very good coexistence with the wildlife"*⑨
- *"during night wildlife come closer to the bomas for protection against the predators; they feel saver close to the Maasai"*⑨
- *"most wildlife do not care about the grazing of cattle"*⑨
- *"crop farming can affect the movement of wildlife but not livestock grazing"*⑨
- *"there are no fences around farms in the area"*⑩
- *"most of the time wildlife and cattle are grazing together, but the disturbance is species specific"*⑩

7.2.5 Stakeholder functions

Table 39: Ranking of the interviewee's engagement in the three land use forms: cattle farming, hunting and conservation

Code	Cattle farming	Hunting	Conservation
HVL-1	0	3	1
HVL-2	0	3	1
HVL-3	3	0	1
HVL-4	3	3	2
HVL-5	3	0	2
HVL-6	0	3	1
HVL-7	3	1	1
HVL-8	0	1	3
HVL-9	3	0	1
HVL-10	0	0	3
LOV-1	0	3	1
LOV-2	3	3	3
LOV-3	3	0	3
LOV-4	3	0	3
LOV-5	0	3	1
LOV-6	3	2	3
LOV-7	0	3	3
LOV-8	0	3	3
LOV-9	3	3	1
NAM-1	3	1	0
NAM-2	0	1	3
NAM-3	1	3	2
NAM-4	3	1	3
NAM-5	0	3	2
NAM-6	3	2	1
NAM-7	3	2	1
NAM-8	3	2	0
NAM-9	3	1	2
NAM-10	3	1	0
NAM-11	3	1	1
NAM-12	3	2	1
NAM-13	3	1	1
NAM-14	2	2	2
TZ-1	3	0	0
TZ-2	3	0	0
TZ-3	3	0	0
TZ-4	3	0	0
TZ-5	1	0	3
TZ-6	0	0	3
TZ-7	0	0	3
TZ-8	0	0	3
TZ-9	3	0	0
TZ-10	0	0	3

7.2.6 Basic farm parameters

Table 40: Basic parameters of the interviewees' farms in Havelland

Interviewee no.	3	4	5	7	9
% of income from livestock farming	20	70	50	50	33
Number of cattle	200	600	60	250	80
Area of pasture (ha)	250	500	35	150	130
Cattle/ha pasture	0.8	1.2	1.7	1.7	0.6
% of pasture used for grazing	64	30	100	50	50
Number of paddocks	5	12	5	12	7
Average distance between cattle and farm (km)	1	2	1	1	1
Area of arable land (ha)	850	700	54	150	130

Table 41: Basic parameters of the interviewees' farms in Lower Oder Valley

Interviewee no.	2	3	6	9
% of income from livestock farming	70	100	90	50
Number of cattle	100	80	33	900
Area of pasture (ha)	500	45	180	250
Cattle/ha pasture	0.2	1.8	0.2	3.6
% of pasture used for grazing	30	56	89	100
Number of paddocks	12	20	10	10
Average distance between cattle and farm (km)	2	6	15	3
Area of arable land (ha)	700	55	80	1500

Table 42: Basic parameters of the interviewees' farms in Etosha Region

Interviewee no.	1	4	6	7	8	9	10	11	12	13
% of income from livestock	100	50	70	100	70	25	100	65	60	75
Number of cattle	1.400	78	415	250	380	130	130	500	600	500
Area of pasture (ha)	28.000	8.000	16.000	6.728	9.500	3.500	3.950	7.887	7.000	7.000
Cattle/ha pasture	0,7	0,017	0,03	0,04	0,04	0,04	0,03	0,06	0,09	0,07
% of pasture used for grazing	71	56	100	100	100	100	100	100	100	100
Number of paddocks	100	10	60	22	52	14	26	24	13	37
Average distance between cattle and farm (km)	30	6	15	15	13	5	7	6	9	11
Area of arable land (ha)	0	0	0	0	0	0	0	0	0	0

Table 43: Basic parameters of the interviewees' farms in Serengeti Region

Interviewee no.	1	2	3	4	9
% of income from livestock farming	60	50	30	40	40
Number of cattle	52	15	40	67	70
Area of pasture (ha)	1	1	5	24	4
Cattle/ha pasture	52	15	8	2.8	17.5
% of pasture used for grazing	100	100	100	100	100
Number of paddocks	1	1	1	1	1
Average distance between cattle and farm (km)	1	2	3	3	1
Area of arable land (ha)	3.2	19.4	3.2	4.5	0

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9 Declaration

I, Thomas Rottstock, hereby declare that this dissertation, is my own work and that I did not use any aids and assistance apart from the ones indicated (in accordance with § 6 [3]). The dissertation or parts of it have not been submitted, accepted or rejected by another scientific institution. Furthermore, there was no collaboration with commercial doctoral consultants. I have not applied for a doctoral degree elsewhere and have no corresponding doctoral degree. I have taken note of the doctoral regulations on which the intended procedure is based. The principles of Humboldt-Universität zu Berlin to ensure good scientific practice were complied with.

Berlin, March 29th, 2021

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Thomas Rottstock